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ANIMAL HUSBANDRY IN THE TROPICS.

It is not very far from the truth to say that the history of the present phase of the work of most Agricultural Departments in the Colonial Empire began a few years after the end of the Great War. For it was not until some years after the chaos of the war period that most of the departments were re-organised and expanded. Taking advantage of the advances in agricultural science in general that had occurred in the interim, they then embarked upon their work anew. Judging from the various Journals in which the results of this work are published, this Journal itself among others, the impression would be gained that their programmes are concerned almost solely with the problems of crop production. The production and introduction of varieties of crops which have a heavier yield, a better quality or a greater immunity from disease; the improvement of methods of cultivation of crops, their preparation or their marketing—these, if one judged by the publications alone, would appear to be the matters with which most of the Colonial Agricultural Departments have been almost exclusively concerned since the War. This was but natural: for it was by such work that economic results could be relatively quickly obtained, to give a financial return to the country for the money expended on the department. It was even more natural that our publications should deal mainly with these subjects. The study of methods of improving the fertility of the soil takes a long time, and practical results, and still more, data suitable for publication, come forward but slowly.

Few of the departments had, however, been so neglectful, as might appear, of the more basic problems connected with the soil itself rather than the crops which grow on it; and it has been very noticeable that there has been a marked increase in the attention devoted in the tropics to these more basic problems in recent years. We hope that it is indicative of this increased interest in the fertility of the soil that we are able to publish in this number a paper dealing with the growth of cattle in Tanganyika. If that paper will not bear comparison with the generality of the papers recording studies of crops, that again is symptomatic of the present

condition of agricultural work in the tropics. For there is a long way to go before the work of the Agricultural Departments in the tropics in connection with animal husbandry reaches the level of their current work on crops.

It is not, we think, far-fetched to look upon a paper about the growth of cattle as an example of an increasing interest in the fertility of the soil. For it is believed that, in most parts of our Colonial Empire, if the fertility of the soil is to be improved in any permanent manner, it will be done through mixed farming, and it is mainly on account of mixed farming that the tropical agriculturist is interested in animal husbandry. The practical alternatives to mixed farming are artificial manuring or green manuring. Taking the broad view of the Tropics as a whole, it would seem that an opportunity for the profitable manuring of a tropical soil with artificials must be regarded as an exception rather than the rule. Such exceptions are, from every point of view, generally most important. The soils derived from the sedimentary rocks of the West Indies are notable among such exceptions; and there are other important exceptions. Yet it still seems a fair generalization to say that the results from manurial experiments with artificials in the tropics have, on the whole, been more variable than in temperate climates. In certain instances, a marked and profitable response to some form of artificial manuring is regularly obtained; but very frequently the response is absent, or is so small that the manuring results in a financial loss, and certainly in no such considerable and reliable profit as would encourage the farmer, whether he be a proprietor or a peasant, to risk his money on artificials. At the best, it is clear that success is only obtained when the manuring programme is based upon such extensive knowledge as can only be derived from a very considerable series of manurial experiments with the particular crop and the particular soil in question.

Again, the results from green manuring have also been generally disappointing. In Southern Nigeria, very extensive trials of green manuring have been carried on now for sixteen or seventeen years. Some fields on the experimental stations of that country have, by green manuring, been kept in constant cultivation throughout that long period; and the crops are still as good as when the experiments were started. This is a result which is more favourable than could have been expected with any certainty when the work was started. It has also been shown that this system of farming is economically sound in the local conditions, as judged by the cost of production of the crops. But local farmers have shown little enthusiasm for the system and still prefer their own old system of rotational bush fallowing.

The results from farmyard manure on tropical crops, especially arable crops, are in marked contrast to those from artificials or green manures. With "pen" manure, there is no question of some soils or some crops giving a satisfactory response sometimes; nor is the response one that can only be demonstrated by elaborate experiments and statistical studies. If any field of almost any arable crop on almost any tropical soil is merely divided into two, and if one half of it is given a dressing of farmyard manure, while the other remains untreated, the difference in the crop's yield will be one that any farmer, or anyone else for that matter, can see and admire.

What is not always so fully appreciated is that, under a rational system of mixed farming in the tropics, the saleable animal products are produced at less than no cost at all, apart only from the labour of tending the stock. For it is becoming clear that, if 100 acres of land under an extensive system of farming produce a given quantity of grain or other saleable products, that same land will almost always produce a great deal more of those same products if it can also be made to produce, in addition, some saleable animal products; or in other words, if the unsaleable by-products of the grain and cash crops can be fed or bedded to stock, and the manure returned to the land.

This fact is gradually being appreciated in most countries of our tropical Colonial Empire; and it is clear that the study of the many problems involved in animal husbandry in the tropics and in the use of the animal manure to the best advantage in a rational system of agriculture must form a large part of the programme of most of these Departments, comparable in many instances with their programme for work on crops. This must involve a very considerable change in the whole strategy of the attack on the great general problem of more and better agriculture in the Tropics; and this in turn calls for a similar change in the training and equipment of the attacking army.

The training of the recruits, or at least of some of the recruits, for the agricultural service, should be such as to make them into good scientific stock men; and as opportunity arises, provision must be made everywhere for more experimental work and study of tropical stock and of the problems of stock feeding and breeding in the tropics. The knowledge thus gained in any one colony should be put at the disposal of all the others through the medium of our technical Journals. Eventually, we hope, the time will come when text-books of these subjects will be possible, comparable with those upon the breeding and feeding of the farm stock of temperate climates. There is in this subject a wide and fascinating field for work of great and permanent value: and it is a field which is still very nearly wholly in its virgin state: just here and there a little preliminary clearing has been done, but that is all. It is time for that field to be taken into cultivation.

THE LIVEWEIGHT DEVELOPMENT OF CERTAIN SHORTHORNED ZEBU CATTLE IN TANGANYIKA TERRITORY.

By M. H. French, M.A., Ph.D., Dip. Agric. (Cantab.).

The following article by Dr. French of the Veterinary Department, Mpwapwa, Tanganyika is published in the hope that others, who are as equally well placed, will record and publish facts regarding birth weight, liveweight increases, measurements of growth, &c., of groups of cattle under their control.

In the article Dr. French assumes that weight is closely correlated with growth. By means of analyses of hay made from herbage cut at different ages he shews the progressive deterioration in digestibility due to age, and assumes that this is representative of the pasture eaten by Zebu grazing stock during the period. In the district in which the work was carried out rains normally commence towards the end of November and continue until the end of April, the dry season extending from May to about the end of November. It is shown that the average live weight curve follows the season fairly closely, particularly with animals over 18 months, and becomes more pronounced as the animal presumably increases in size so that its total annual intake is averaged out at a maintenance at almost 6 years of age.

The experiment, starting with four native or Zebu calves, three near to death, in which the ration given was a good one to induce increase in liveweight, shews the relative response of Zebu cattle to steady and good feeding, whilst the comparison with Ayrshire grade calves presumably fed equally well, brings out the capacity for earlier maturity in the grade over the native Zebu.

It is regrettable that the data submitted should be based on the average weights of only four head of cattle. But there is a great scarcity of published data of this kind in reference to Zebu cattle in Africa, and in these circumstances accurate data about even such a small herd is much better than none at all.—[Editor.]

In Tanganyika Territory there are about five million native-owned cattle, a number greater than that owned by the natives of any other country under the jurisdiction of the Secretary of State for the Colonies. Even so, many more cattle could be supported were it not for the limiting factors of disease, scarcity of surface water, and seasonal shortages of food. Except for a small number of the long-horned *Sanga* (Ankole) type of cattle these native-owned animals are representatives of the *short-horned* zebu type.

The short-horned zebu is a hardy animal possessing a skin of thin to medium thickness covered with short fine hairs which can be of almost any colour. It is usually considered a small, slow growing animal. The hump, the narrow sloping hindquarters, the deep chest and the exaggerated development of the dewlap are conformational characteristics. In a large territory such as this it is to be expected that the great range of topographic, climatic and vegetational conditions would lead to the development of distinct local variations. It is easy, in fact, to differentiate certain local breeds according to their size, *e.g.* the large animals of certain parts of Masailand and Ugogo, the smaller Southern Highland cattle, and the still smaller cattle from the overstocked areas of the Lake and Central Provinces, and finally the dwarfed cattle of the Wakara and Wachagga tribes. McCall (1) with his much wider experience and from a study of "the peculiar and distinctive characteristics manifested in individuals of the zebu rather than those observed collectively in herds," recognised that animals possessing a distinctive colour and conformation appeared in widely separated localities. He established four such herds which, in a number of cases, seemed to breed true.

It is obvious, therefore, that to speak of the growth rate of short-horned zebus is comparable to referring to the growth of British cattle. In this paper, the figures for native-owned zebus refer to the medium sized breed found in Ugogo and do not include the larger and smaller breeds found in other localities.

Hornby (2) has pointed out that the native husbandryman is only capable of maintaining herds "on land the vegetation of which is indicative of arid or sub-arid conditions." The reason being that in the wetter and better grazing areas the conditions favour ticks, worms, biting flies, and hordes of other parasites against the ravages of which the native is helpless without veterinary aid. By concentrating stock on the drier arid areas, where conditions are unfavourable to parasites, a state of overstocking results which renders the environment still more unsuited to the continued existence of these pests. A further consequence of this overstocking is a dry season period of under nutrition caused by an absolute shortage of grazing. I have previously (3) recorded the growth weights of nearly mature native oxen and it was shown that, even when living under good native conditions, the oxen lost nearly as much weight in the dry season as they had gained during the previous period of abundance. In the badly overstocked areas this loss of weight during the dry season becomes much more serious and many animals die of starvation. It is estimated that on an average approximately 200,000 cattle die annually from starvation, but this must be regarded as the premium paid by the native stock-owners for a guarantee of freedom from stock losses arising from causes they do not understand. Death from starvation they understand but their primitive minds do not comprehend the action of parasites of whose very existence they are unaware.

The bottom curve in Figure 1 records the rate of liveweight increase of native cattle under Ugogo conditions from birth until seven years of age. The same animals were not followed right through

and there are many more animals averaged for the period after two years of age than for the early part of the curve. The first part of the growth curve represents the average of calves born at the beginning of the rainy season but there is a wider range in the season of birth for the animals recorded in the later portions. It is seen that growth during the first three years is fairly rapid during the rains but that the rate of liveweight increase is then slowed down considerably. The periods of liveweight loss are confined to the latter part of the dry season and the first month of the rains. The animals then put on weight until about the middle of the next dry period. The variations in the extent of the gains made during the rains are due to the differences in the quantity and quality of the grazings and to the efficiency of the herd boys.

Previous work (4) has shown that the average liveweight of full-mouthed cattle (male and female) killed in the Mpwapwa abattoir during a complete year is 500 lb. Figure 1 indicates that under good conditions heavier weights can be reached but it is easy to see that shortage of food due to poor grazing years or overstocking, long treks in search of water, disease, and inefficient herding could cause a serious interference with this normal rate of growth. Very few, if any, native herds succeed in escaping the many diseases of a non-fatal character from which they are liable to suffer, and their growth curves are thus flattened out because any retardation of growth during the rainy period usually means that the animal finishes that year at a lower weight than when he started it.

The undulating shape of this growth curve follows closely the variations in the feeding values of the grazings. In Table I are given the compositions of one of our good grazing grasses, *Cynodon plectostachyum*, when cut at intervals of one to six month's growth. It is seen from these figures how the feeding value varies with increasing age of the grass and the onset of the dry season after the fourth month.

The falling protein content with increase of the fibrous constituent is a normal feature of all grasses, and with these age changes comes a decrease of digestibility. Table II gives the digestible nutrients and feeding values of hays made from mixed grasses. These hays were made from the same field at different times of the year, and the digestibility studies were made with adult zebu oxen.

It may be wondered why the feeding values of such mature grasses have been determined, but under the present methods of native husbandry certain areas are not grazed at all during the rains and the cattle are moved on to these ungrazed areas when the grazings and water nearer home become exhausted. In the early part of the dry season cattle do well on the dried up grasses but it is from the middle of July, when the quantity of available grazings is becoming rapidly reduced, combined with the dwindling quality

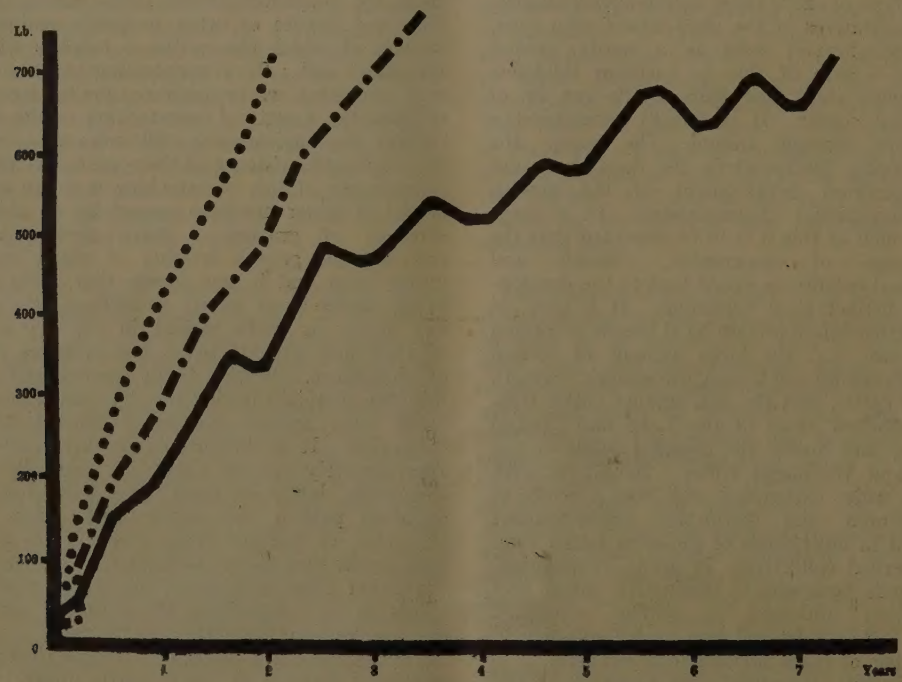

Fig. 1.—Liveweight growth curves of short-horned Zebu Cattle under normal conditions (bottom curve), and when well fed (middle curve), compared with growth rate of three-quarter grade Ayrshire bulls (top curve).

TABLE I.—Composition of Cynodon plectostachyum at Different Ages.

(Dry Matter Basis).

	1 Month.	2 Months.	3 Months.	4 Months.	5 Months.	6 Months.
Crude Protein	15.67	11.39	10.06	10.09	8.07	7.19
True Protein	12.78	8.82	8.16	8.15	6.69	5.78
"Amides"	3.00	2.57	1.90	1.94	1.38	1.41
Ether Extract	3.27	2.82	2.87	2.21	1.97	1.86
N-Free Extract	40.74	43.09	42.66	42.46	42.88	42.87
Crude Fibre	28.88	34.01	35.78	36.72	39.02	39.51
Total Ash	11.33	8.69	8.63	8.52	8.06	8.57
SiO_2 Free Ash	6.79	4.37	3.77	4.56	3.96	4.57
CaO	1.04	0.96	0.93	0.76	0.72	0.70
P_2O_5	1.06	0.71	0.59	0.63	0.63	0.60

TABLE II.—Digestible Nutrients and Starch Equivalent Values of Hays made from the Same Grasses at Different Stages of Maturity.

(Per 100 Parts Dry Matter).

	Hay from Grass 6 Weeks old.	Hay from Grass 22 Weeks old.	Hay from Grass 38 Weeks old.
Digestible Crude Protein	6.13	3.75	1.19
Digestible Ether Extract	0.28	0.10	0.21
Digestible N-Free Extract	28.04	21.67	23.67
Digestible Crude Fibre	19.68	19.88	15.86
Digestible Organic Matter	54.13	45.40	40.93
Starch Equivalent Value	35.80	23.75	19.75
Nutritive Ratio	1:8	1:11	1:34

of the herbage, that liveweights begin to drop. Normally the grazings are helped out by allowing the stock to feed on the weeds and residues from the arable lands, but when these too become exhausted the plight of the native owned zebu is very sorry, and liveweight losses occur at accelerated rates.

Figure 1 indicates that the weight of zebu cattle tends to become stabilised between 650-700 lb. about the 7th year. Whilst many animals never reach this weight, it is equally true that all over the Territory there are outstanding oxen weighing upwards of 800 lb. living in herds whose average weight for full-mouthed animals is very much less. So constantly are these few large animals encountered that this investigation was planned to obtain some idea of the growth rate of zebu cattle under good native conditions. It was also decided to get an idea of what would be the rate of growth and potential maximum development of these zebus when fed and managed well, and when sheltered, as far as possible, from local parasitic infections.

Four native bull calves were obtained to get an idea of the potential growth rate of the zebu. These four animals were not picked animals and all were allowed to remain entire. Subsequent work has however shown that better rates of growth would have been obtained had these animals been castrated because at intervals they exhibit an intense sexual desire, become very restless and actually lose weight. One of these bulls was purchased in the open market at seven days old almost at the point of death from starvation. His dam had no milk and the calf was unable to stand—he now weighs 850 lb.

at under 4 years of age. Another calf was from a stunted heifer who also had no milk. This calf also nearly died and at 3 months old weighed only 10 lb. more than at birth. The third bull was from a cow sold because her previous calves had died of starvation through lack of milk, whilst the fourth bull was from a good native cow. These calves were fed whole milk till 3 months old and then given skimmed milk for another two months. They have been allowed grazing during the day time but received hay and a concentrate at night. The middle curve of Figure 1 represents their average rate of growth.

Alongside these four zebu bulls, three three-quarter grade Ayrshire bulls have been reared under identical conditions. Their rates of growth are shown by the top curve of Figure 1.

Whereas the grade Ayrshire bulls reached 700 lb. at 2 years old the zebu bulls did not reach this weight until a year later. The introduction of European blood has thus increased the size and rate of growth very appreciably. On the other hand the growth of the four zebu bulls is very different from that normally found in native herds and indicates that, in spite of the retardation and stunting for a long period of time, the zebu still retains a much higher potential growth rate than that which finds expression under our hard local conditions. Although these bulls have reached at 4 years old the same weight as the best native-owned oxen reach at 8 to 10 years there is a very significant conformational difference to be observed. These young bulls have not attained anything like the skeletal growth of the large oxen reared under normal conditions; they are very considerably smaller in height, their length is not so great, and they are very much "nearer the ground". It is hoped that it will be possible to discover whether this smaller stature is a result of the more intensive feeding conditions or whether they will eventually reach the same height as the large Masai oxen. With their rounded quarters, well fleshed ribs and loin, and their immense humps, they are so compact and well proportioned that visitors invariably underestimate their weights.

These bulls are extremely attractive animals in appearance and many people would pick them out as first class animals of their breed. The old adage that "half the breeding is in the feeding;" holds with particular emphasis for the zebu, in fact one might say that when judged as a beef animal all the breeding depends on the feeding. One is frequently being impressed by a well fed, sleek, well proportioned zebu and yet, when for some reason this animal loses its condition and weight, it is extremely difficult to pick out any character distinguishing it from any other thin zebu. The results with these zebu bulls have emphasized the beneficial effect of improving the plane of nutrition of the short-horned zebu of this Territory. I do not pretend that the plane of nutrition employed in this investigation is justified economically but it is very certain that much could be done to improve the grazing conditions of the native-owned zebus. Particularly is this true for the latter part of the dry season, when anything to reduce the downward trend of the liveweight curve would do much towards improving the rate of growth.

The native of Tanganyika looks complacently upon this annually recurring spectacle of grazed out pastures and starving stock at the end of the dry season, and so familiar is this sequence that nothing is done to mitigate its worst aspects. Yet it is certain that by education the native can be taught to conserve grass and crop residues (particularly legumes) in the form of hay, for the feeding of his stock in the second half of the dry season. It is even possible that he might consider the making of grass silage in pits, whilst stall feeding for the production of manure would become a normal feature. With the recognition of quality instead of stock numbers the purchase of foodstuffs such as cottonseed, oil-mill residues, and the by-products of the cereal foods would follow. This state of affairs is a very long way off, but we can derive much hope for its eventual attainment, in certain suitable localities, from the fact that where economic pressure is sufficiently great, as in Ukara and Uchagga, the natives are already stall feeding their cattle and utilising their crop residues for the feeding of their animals. Meanwhile the policy of rotational grazing introduced by this department will do something to reduce the annual losses from starvation, as well as to control erosion.

Summary.

(*i*) Owing to seasonal rainfall, short periods of good grazing alternate with long intervals of drought. As a result the liveweight curve of zebu cattle follows an undulating course.

(*ii*) The shape of the growth curve can be correlated with the variations in the feeding values of the grazings.

(*iii*) Under good native conditions the zebus grow well during their first three rainy seasons but their weight becomes stabilised around 650-700 lb. at 7 years old.

(*iv*) Given good feeding conditions a very much accelerated rate of growth is attained. The stunting of innumerable generations by our hard conditions has not destroyed the capacity for greater growth rates than the ones usually exhibited.

Acknowledgment.

I am indebted to Mr. H. E. Hornby, the Director of Veterinary Services, for permission to carry out this work and to publish the results.

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THE CULTIVATION OF PERENNIAL FODDER GRASSES IN TRINIDAD.

By D. D. Paterson.

Experiments with perennial cultivated fodder grasses carried out on the farm of the Imperial College of Tropical Agriculture during the last seven years have produced results of some interest to local stock farmers, and especially to those who are using a soiling system of feeding their animals. In the references cited, the data from the individual experiments are recorded and analysed in detail and this paper is in the nature of a précis with particular attention to points of practical importance to livestock owners in Trinidad. The College Farm is situated on the line dividing the sandy schist soils of the Northern Range from the heavy alluvial loams and clays of the Central Plain of Trinidad. The farm soil may be classified as a sandy or gravelly loam of no great depth, naturally acidic in character and rather poor in plant foods. The experimental evidence upon which the following recommendations are based, is derived from field trials on this one soil type. In consequence, while major yield and quality differences may safely be assumed to apply to a wide range of environmental conditions in Trinidad, finer distinctions may require some modification in areas where the soil or other factors are markedly different from those obtaining on the College Farm.

In these experiments, the following perennial fodder grasses, arranged in descending order of importance, were tested.

	Relative Yield of Crude Protein.* *Per cent. of Elephant grass.*
(1) Guatemala Grass (*Tripsacum laxum*)	92
(2) Para Grass (*Panicum barbinode*) †	96
(3) Elephant Grass (*Pennisetum purpureum*—var. Uganda)	100+‡
(4) Elephant Grass (*P. purpureum*—standard variety)	100
(5) Coimbatore Cane (*Saccharum sinense* var. *Co.* 213)	70−‡
(6) Uba Cane (*S. sinense* var. *Uba*)	65
(7) Guinea Grass (*Panicum maximum*)	65−‡

Cultural Practice.

There are certain features in the cultivation of these grasses common to all. A perennial fodder crop will generally remain on the same land for a number of years, and prior to planting, a thorough and deep cultivation of the soil with particular attention to the burial of weeds is particularly desirable. A well tilled soil promotes good root development in the young stools and gives the crop a much better chance of smothering weed competition. With this object in view, also, a relatively close spacing is to be recommended, and some intercultivation between the rows will generally be necessary for the first year after planting. After that time, a good fodder crop should be thoroughly established and under skilled management as regards manuring and harvesting it should be able to dominate the weeds without much further cultural attention. Perennial fodder grasses are most commonly propagated vegetatively from root or stem cuttings. Planting should be timed so as to begin shortly after the wet season has definitely started which in a normal year in Trinidad would be from the end of May to the beginning of August. This date of planting should ensure humid conditions of soil and atmosphere for the ensuing six months, and encourage rapid and profuse sprouting of the sets. The stools should be thoroughly established by January when the dry season usually begins, and the plants should be able to contend successfully with the semi-drought conditions which are liable to occur during the first quarter of the calendar year. On the soilage system of management a large tonnage of green herbage containing 15 to 20 per cent. of dry matter will be removed from the land each year, and if high yields are to be maintained for long periods, this steady drain on the soil will have to be balanced by the application of an appropriate fertiliser from time to time. On the assumption that the nitrogen constituent is the one most likely to become the limiting factor for a herbage crop, regular dressings of farmyard manure or compost would be very suitable, but the cost of manufacture and application might be excessive. A complete artificial fertiliser or an appropriate mixture, with a high proportion of nitrogen might be equally effective, especially if it is applied frequently in light doses. Any appropriate manurial programme will not only guarantee good yields, but will also maintain at a high level the quality of the herbage as regards its protein and mineral content. Chemical analysis of the herbage from the various experiments at the College have shown that under cultivated conditions with regular manuring, the mineral content of any of these fodder grasses cut at a young enough stage of development is adequate to fulfil the maintenance requirement of tropical livestock. In contrast to this, analytical data for many species of tropical grass show that in general this is not likely to be equally true of the same grasses continually grazed or otherwise utilized without any equivalent return to the soil. The need for manuring is therefore two-fold in that it is required for the maintenance of both quantity and quality in perennial fodder crops.

* Based on experimental data for the optimum cutting rotation and appropriate harvesting technique.

† A recent note from Kew points out that *Panicum barbinode* is a synonym for *Brachiaria mutica* (Forssk.) Stapf and that the latter is the correct generic name for Para grass.

‡ Exactly comparable data are not available for these grasses: the experimental evidence is sufficient to show whether the required value is above or below a certain level as indicated by the recorded figure with a plus or minus sign respectively.

The seasonal variation in yield and composition of all these fodder crops is very marked. In general, in the dry season the gross yield of herbage will be greatly reduced, the actual percentage reduction varying with the variety of fodder grass. In contrast, in all varieties the dry matter content and nutrient value, weight for weight, is distinctly higher in the dry season than in the wet months of the year. The maintenance rations quoted hereafter are based on the quality of the green produce in the middle of the wet season; at the height of the dry season it can safely be assumed that the weight of green matter required for maintenance may be reduced by 20 to 30 per cent. without any loss of nutrient in the ration.

Under local conditions of soil and climate, the first four grasses listed are all excellent fodder crops, and with an appropriate system of management, each of them is capable of giving high yields of good quality herbage for prolonged periods. They are all about equally good in their ability to smother weed growth. Para grass is more efficient as an eradicator of low creeping types of weed, while the other two grasses cope more effectively with upright tall species of weed. In comparison, the last three species mentioned in the list are for various reasons decidedly inferior fodder crops. The best grass to select out of the first four will depend on environmental and other factors, and it is proposed to discuss each one separately, indicate briefly its good and bad points, and outline an appropriate cultural technique.

Guatemala Grass.

This has been ranked first, as it has shown itself to be the best general utility grass although it does not give quite the highest yield of herbage or of nutrient per acre. It is hardy and persistent and maintains a high level of productivity throughout the year showing the least monthly fluctuation from the wet to the dry season. It is best propagated by root division from old stools, two to three tiller sections being preferable to single tiller units. The planting distance may be from 2 by 1½ feet to 3 by 2 feet between stools, the closer spacing probably being an economy in the long run as it will reduce the amount of inter-cultivation in the establishment period, and tend to more effective weed control by the crop itself. The interval between harvests should be from eight to ten weeks, as this will ensure both good yields and high quality of herbage. The stools should usually be mown from 9 to 12 inches above ground level as high cutting encourages more rapid development of the ratoon crops. This may lead to a gradual accumulation of organic débris at the base of each stool, and it is advisable to disperse this accumulation by taking an occasional harvest at three inches above ground level. Using the cutting rotation suggested, it is estimated that 60 lb. of herbage will supply 6 lb. starch equivalent and provide an adequate maintenance ration for an ox weighing 1,000 lb.

Up to 1938, crops of Guatemala Grass grown in Trinidad appeared to be singularly free from pests or diseases, but in February of that year, the grass became heavily infected with a rust fungus (*Puccinia polysora*). At the time of writing, this fungus is still prevalent in the crop, though the intensity of the attack has diminished considerably. It is thought that this fungal outbreak may be correlated with the unusually wet weather that has endured for the last 18 months, and it is hoped that the fungus may have little ultimate effect on the cropping quality of the grass. On the other hand, if the present rate of infection continues, it will undoubtedly mean, at the least, a marked decrease in the yield of herbage.

Para Grass.

The gross yield of green herbage from this grass is lower than that obtained from either Guatemala Grass or Elephant Grass, but its high percentage of dry matter and crude protein is such that the yield of nutrient per acre is not inferior to that of the other two species. Para Grass thrives best in humid conditions of soil and climate, and in very wet localities it is decidedly the best fodder crop of the three. It has three rather obvious disadvantages. It is an obnoxious weed if it is allowed to spread on to arable land; it gives a negligible yield of herbage in the dry season of the year, and its tangled habit of growth makes it difficult to harvest. Para Grass is best propagated by spreading the uncut runners in a continuous line two to three thick in shallow furrows two feet apart. The stolons or runners should be lightly covered with soil one to three inches in depth, and the field should then be rolled to bring the nodes on the runners in close contact with the soil. The crop should be cut over every six to eight weeks in the wet season and left undisturbed during prolonged drought periods. The produce is best cut some three inches above ground level removing only the young herbage and leaving the rather dry and fibrous stolons to produce fresh sprouts for the succeeding ratoon crop. An adequate daily maintenance ration for a working ox is 50 lb. of green herbage.

Elephant Grass.

This is the fodder crop that is capable of giving the largest gross return of bulk herbage and nutrient per acre. It has a high moisture content and is very succulent and palatable. Like Guatemala Grass, it is most easily propagated from root division, but a wider spacing should be used, with rows three feet apart and 1½ to 2 feet between stools in the row. Elephant Grass thrives best on well drained soils in areas of high evenly distributed rainfall. This grass will survive satisfactorily the normal dry season in Trinidad, but the reduction in productivity is much more marked than in the case of Guatemala Grass. During the wet season, however, the rate of growth of Elephant Grass is very rapid and unless

it is cut frequently there is a danger that the culms may develop into pseudo-canes at the expense of the foliage. Only seven to eight week intervals should be allowed between successive harvests of this grass, which is best mown some three to six inches above ground level. Due to its low percentage of dry matter, the starch equivalent value of the produce is less than that of the other two fodder grasses, and on an eight-week harvesting rotation, 80 lb. of green produce will be required to supply the daily maintenance ration for cattle.

On account of its exceptional productivity, Elephant Grass is deservedly one of the most popular of colonial fodder crops, and is widely cultivated all over the tropics. It suffers in Trinidad from the serious drawback that it is subject to sporadic but severe attacks of a *Helminthosporium* sp. fungus which in certain seasons not only reduces the yield of herbage to a negligible amount but is even capable of causing considerable mortality in the individual stools. *Helminthosporium* spotting of the leaves of Elephant Grass occurs in some other tropical colonies, but it is not reported to have had any marked effect on the productivity or quality of the herbage. Severe attacks appear to be correlated with some peculiar combination of climatic factors—probably linked with prolonged high humidity—appearing occasionally in Trinidad. There is reason to believe that some strains of Elephant Grass are partially resistant to this fungus, and two of these strains are being tested on the College Farm with promising results. One of these is a sport from the local variety of Elephant Grass, and the second is a new strain recently introduced to the Colony from Uganda. At this stage, it is impossible to say whether the degree of resistance of either of these strains is adequate to allow the grass to withstand successfully a really bad season, but it *is* sufficient to make it advisable to use in preference one or the other of these strains in the planting of any new fields of Elephant Grass.

Useful Data.

The fundamental data upon which these various recommendations are based are summarised below. They represent mean values, obtained from the experiments on the College Farm, and are estimates of the yield and composition of the best fodder grasses when the cultural technique conforms to the one suggested as appropriate to each species. A marked change in either the soil type or the season will entail considerable modification of these estimates,chiefly in the yields but also to a less extent in the nutrient and mineral constituents of the produce, and further experiments to test the reactions of these species to different environmental conditions are under consideration. Future research will also have to be extended to include the testing of likely exotic species and varieties, some of which may ultimately prove greatly superior to any of the existing fodder crops. Another very important branch of this research on forage crops is the problem of pasture management and improvement. While it is hoped that the foregoing recommendations represent a satisfactory advance on existing practice, it is fully realised that they can only be of temporary utility, until such time as further experiments over a much wider field of investigation have supplemented the available information on tropical fodder crops.

	Guatemala Grass.	Para Grass.	Elephant Grass.
Yields.	*Tons per acre per annum.*		
Fresh herbage ...	42.40	40.00	63.80
Dry matter ...	8.09	9.74	9.31
Crude protein ...	.569	.600	.624
Composition.	*Percentage of fresh herbage.*		
Dry matter—			
wet season ...	18.64	21.60	13.65
dry season ...	27.69	32.65	19.48
Crude protein—			
wet season ...	1.31	1.29	.90
dry season ...	1.88	1.69	1.33
	Percentage of dry matter.		
Crude protein ...	7.03	6.07	6.68
Carbohydrates and fats ...	48.03	48.82	44.99
Crude fibre ...	34.14	34.78	33.36
Total ash ...	10.80	10.33	14.97
Minerals.	*Percentage of dry matter.*		
CaO	.410	.664	.902
P_2O_5	.764	.880	1.222
Na_2O	.034	.259	.036
Nutritive Values.	*Per cent.*		
Starch equivalent (wet season sample) ...	10.6	12.9	7.8
Nutritive ratio ...	1 : 11	1 : 13	1 : 11

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SOIL EROSION IN ST. VINCENT, B.W.I.

By F. Hardy.
(*Imperial College of Tropical Agriculture*).

The soils of St. Vincent have been mainly derived from loose, fragmental volcanic ejecta, such as boulders, stones, cinders, sand and ash. These materials would not be expected to erode very rapidly, because their high permeability to water should allow rain to penetrate freely without disturbing the surface layers. Nevertheless, the soils derived from them exhibit striking differences in their liability to erosion, and a study of the factors that account for these differences may prove useful in deciding the best means for conserving the soil, not only in St. Vincent, but also in other West Indian Islands of similar geological origin, for example, St. Kitts, Montserrat, and parts of St. Lucia, Grenada and Dominica.

(I) Erosion Factors.

The rate of soil erosion, measured as the quantity of soil removed in a given time, depends chiefly on (*a*) the amount, intensity and duration of the rainfall, (*b*) the area and slope of the land surface on which the rain falls, (*c*) the extent and nature of the vegetation cover, and (*d*) the properties of the soil itself.

(1) Rainfall and Topography.

In St. Vincent, rainfall conditions are very favourable to erosion. The amount of rain varies from 60 to 140 inches a year, the leeward region being drier than the windward, and the highlands the wettest of all. The rain generally falls in heavy showers during the six months' wet season, sometimes as much as 5 inches falling in a day, and occasionally one inch in an hour. The dry season is usually severe, and conditions of intense drought are often experienced, at least in the exposed windward coastal belt. Topography too is favourable to soil erosion. Within the rugged leeward region, angles of slope of 40 degrees or over are not uncommon, but in the windward region slopes are much less steep, being generally below 15°. The slopes of Soufrière, a mountain occupying the northern one-third of the island, rise at an angle of about 15°, but the sides of its radiating ravines are inclined at angles approaching 40°, while the summit of its recent volcanic cone slope at 25 to 30 degrees.

(2) Vegetation and Crops.

Impenetrable rain forest occupies most of the high land above the 1000-foot contour comprising the central ridge of the island. Occasionally forest descends to lower altitudes in the leeward coastal valleys and on the slopes of Soufrière, while cultivated lands encroach on forest within the basin of the Mesopotamia Valley in the southern windward region, where clearings sometimes reach the watershed. For the most part, the windward coastal belt consists of long-cultivated arable land forming a belt of foothill country two miles broad, stretching from Kingstown northwards to Georgetown. It is not known with certainty how long this windward coastal belt has been under cultivation. When the French colonists from Martinique first settled in St. Vincent in 1719, the island was inhabited by Caribs whose cultivations were probably confined to coastal plains and valley flats. Later plantations, established by the European settlers on the lower hillslopes, must have necessitated wholesale destruction of forest.

The first field-crops to be grown were cotton and sugar-cane, though arrowroot was widely cultivated after 1825. Ground provisions, bananas and other annual crops have been intermittently planted from the start, but orchard crops, such as cacao and citrus, have not proved successful, except in a few sheltered valleys. The soil of the windward coastal belt has thus been continuously tilled for at least 150 years, and the favoured crops have mainly comprised open vegetation which exposes much of the land-surface to erosion. Thus, cotton, cassava, pigeon-pea, ground-nut, maize and other annual crop-plants afford little protection to the soil, and their continued cultivation is usually accompanied by rapid soil deterioration, eventually necessitating abandonment of the land to natural grass and weed herbage. Arrowroot belongs to a somewhat different category. The crop is ratooned from pieces of rhizome left in the ground after reaping, and ratooned fields that have not been replanted for 10 or 15 years are not uncommon in St. Vincent. Arrowroot covers the ground very rapidly after planting, but when the rhizomes are excavated during the rainy season (say, in November or early December), or late in the dry season (in May) the land is laid bare to erosion, and heavy rains may cause serious damage just after these periods. Fields older than 8 or 10 years, however, begin to fail through soil impoverishment and the arrowroot crop dies out in patches, so that erosion may again set in. The method of reaping the crop also encourages soil loss, since it consists in the excavation of the rhizomes by hoeing to a depth of 6 to 12 inches. The operation is invariably performed in such a manner that the surface mould is dragged downhill in regular stages. A conspicuous result of this system is the development of small escarpments along the upper boundaries of the arrowroot fields.* Another result is the gradual invasion of the lower grounds and roads by gravitating soil. Furthermore, the constant hoeing tends to break up the clods and crumbs and so to destroy the granular structure of the soil.

* This feature was pointed out to the writer by Mr. C. K. Robinson, Agricultural Superintendent, in June, 1938.

Of all the crops regularly grown in St. Vincent, cotton least protects the soil from beating rain, and least effectively diminishes erosion. This crop is usually sown in rows on contour banks, but adequate provision is seldom made for surface drainage, so that, during heavy showers, the banks frequently break down through the accumulation of water behind them, spilling the water onto the lower banks, and eventually starting erosion channels.

It would therefore appear that climate, topography and the nature of the crops commonly grown in St. Vincent all favour rapid soil erosion, yet over considerable areas of steeply-sloping country, erosion is not so severe as might be expected. Other areas suffer very badly, however, and all the known types of land wastage, from sheet erosion to deep gullying, are well represented. The variation in susceptibility to erosion may be explained by fundamental differences in the nature and properties of the soil-types on which crops are grown in St. Vincent.

(II) The Chief Soil-Types of St. Vincent.

Three main groups of soils have been distinguished, in St. Vincent (1),* namely, (i) Coastal Plain and Valley Alluvial Soils, (ii) Recent Volcanic Ash Soil of the Soufrière District, and (iii) Yellow Earth Soil.

(i) The *Coastal and Valley Soils* occupy flat land near the sea, along valley floors, and at the mouths of small estuaries; they are not liable to erosion, and comprise the most fertile lands of the Island. The material from which they have been derived consists of loose black volcanic sand transported by water from the higher ground during periods of geological denudation.

(ii) The *Recent Volcanic Ash Soil* is in process of formation from fragmental ejecta erupted mainly by Soufrière during its latest activity in 1902-03.

(iii) The *Yellow Earth Soil* occupies the rest of the Island; it shows differing degrees of maturity, as well as great variation in physical features and natural history.

The Yellow Earth Soil presents the most striking erosion features of all the soils of St. Vincent, and for that reason, it will receive most consideration in this article. As a preliminary, the recent Soufrière soil will first be briefly considered, since it yields evidence of the rate at which soil may be formed from volcanic ash under conditions obtaining in the West Indies.

(A) The Recent Volcanic Ash Soil of the Soufriere District.

The development of soil in the Soufrière District was first studied by H. A. Tempany (2), 14 years after the last eruption. Laboratory data demonstrated that between 1.0 and 2.0 per cent. of soil organic matter, containing 0.022 to 0.035 per cent. of nitrogen (carbon : nitrogen ratios, 26.3 and 33.1), had already accumulated in the surface foot layer. Previously, the district had been visited by W. N. Sands (3), who noted that, eight years after the last eruption, the mountain slopes had become clothed as formerly with luxuriant vegetation to an altitude of 2,000 feet, and mosses and ferns had re-established themselves within the new crater. The flora then comprised over 150 species of higher plants, mostly forest trees, but the greater part of the vegetation had sprung from old roots not killed by the hot volcanic ejecta. At the present time, the re-afforested region of Soufrière has attained comparative stability; soil formation is slowly proceeding and keeping pace with, or actually exceeding, surface erosion. In 1933, thirty years after the eruptions, surface soil samples collected by the writer at ten different sites within the Soufrière area showed average organic matter and nitrogen contents of 2.1 and 0.10 per cent. (carbon : nitrogen ratio, 12.2) in the upper 6-inch layer, values which are comparable with those for most of the cultivated soils of St. Vincent. Thus within 10 to 20 years, sterile volcanic ash may give rise to fertile soil under the prevailing circumstances.

Conditions in the rest of St. Vincent, however, are quite different from those in the Soufrière District, since volcanic activity over the greater part of the Island has long been extinct. Soil-forming processes have operated there for a very much longer time, and soil-profile differentiation has become conspicuous, owing to the intense weathering of the parent volcanic ash, the accumulation and penetration of products of plant decomposition, and the leaching effects of percolating water. The resulting soil has a bright tawny-brown colour, darkened in the surface layer by the incorporation of organic matter. When the upper soil has been turned over by tillage, the cultivated fields assume a warm fallow appearance which is very characteristic of the scenery of St. Vincent, especially the Windward Coastal Belt. This soil, derived from older volcanic ash, occasionally interlayered with thin lava flows, has provisionally been termed Yellow Earth.

(B) The Yellow Earth Soil of St. Vincent.

(1) *Geological History.*—Several distinct stages in the development of Yellow Earth may be recognised in St. Vincent, their differentiation depending on the degree of soil maturity. This in turn depends partly on the geological age of the parent volcanic materials, the length of time of their exposure to soil-forming processes, and their permeability to water.

Field evidence indicates that the geological age of the St. Vincent volcanoes varies greatly. At least four separate centres of volcanic activity may be distinguished, namely, (i) Soufrière, the most recent volcano, 4,050 feet high, whose historical eruptions are dated 1718, 1812, 1880 and 1902-03, (ii) Richmond Peak, 3,540 feet high forming part of the Garu Mountain mass, situated at the northern end of the Main Ridge, and separated from Soufrière by a deep depression, (iii) Bonhomme Peaks, 3,190 and 2,430 feet,

* *See* List of References.

situated at the centre of the Main Ridge, (iv) Mount St. Andrew, 2,430 feet, overlooking Kingstown, situated at the southern end of the ridge. The volcanic mass forming the Garu Mountains seems not to be very much older geologically than Soufrière, judging by the fact that the ejecta exposed on the rugged slopes bordering the Richmond and Cumberland Valleys in the leeward part of the island, and those covering the high ground of the Three Rivers District in the windward, are still comparatively unaltered. They consist of unconsolidated, dark-coloured cinders, small stones and ash, piled up into innumerable steep hills, showing comparatively little erosion. The central volcano (Bonhomme), on the other hand, appears to be relatively ancient; its crater has long been obliterated, and its ejecta, where exposed by the road cutting at Belle Isle Hill on the leeward side, is seen to consist of partly-cemented yellow-brown cinders and ash that have been considerably altered by weathering. On the opposite side of the island, the Bonhomme volcanic deposits are less bouldery and stony than those of the leeward side, though they too are much weathered. The southernmost volcano (St. Andrew) is probably the oldest in St. Vincent. The mountain mass here has been extensively denuded, producing rolling upland country, and the river valleys have been reduced almost to their base lines, for example, the Mesopotamia Valley. The agglomerates, ash and thin lava beds comprising the southern highlands are the most decomposed of all the rocks of St. Vincent, and the Yellow Earth soil derived from them shows the most mature profiles.

The volcanoes of St. Vincent were built up on a subsiding narrow submarine ridge, 5,000 feet below the present sea level. The first volcanic eruption apparently occurred some 14 million years ago during late Miocene times. Since then volcanic activity has occurred intermittently to the present day, and has produced a series of great volcanic piles from centres situated further and further north, the last-formed mountain mass being Soufrière. The oldest volcanoes have been the most denuded, though layers of ash of varying thickness were doubtless deposited over the whole area at each succesive eruption. During the Pleistocene era (more than half-a-million years ago), St. Vincent was subject to marine submergence and intermittent uplift, as indicated by the occurrence of flat-topped marine terraces of which six or seven may be identified in the windward region, particularly one at 200 feet, forming the spurs and headlands near Brighton. The fact that similar marine-eroded terraces are not conspicuous in the leeward region is attributed to lesser wave-action along its protected coast-line, and to a downward tilting of that side of the island during its latest emergence (4). The geological evidence thus indicates that soil formation and erosion have been going on for at least half-a-million years in the southern part of St. Vincent, and for a much shorter time in the central part, while in the exposed northern part the processes have been in operation only for a few years. Furthermore, since the topography is less steep in the southern part, soil has tended to accumulate more rapidly than it has been removed, so that here the Yellow Earth shows the deepest and best-developed profiles.

(2) *Yellow Earth Profile Features.*—As represented in the southern uplands (for example the Dorsetshire Hills), the Yellow Earth profile exhibits a sepia to chocolate-brown humic layer up to two feet in thickness, containing between five and two per cent. of organic matter. This grades downwards into a yellow-brown to ochre-yellow subsoil, becoming speckled grey, blue-green and black below the 4 or 5-foot depth. This "pepper-and-salt" appearance indicates the occurrence of partly-decomposed volcanic ash, which originally consisted of brownish-green grains of iron-bearing minerals (hypersthene and augite, 34 per cent.; olivine, ten per cent.), black shiny grains of crystalline iron oxide (magnetite, 12 per cent.), and white waxy grains of lime felspar (labradorite, 44 per cent.). The dark minerals have partly decomposed into ochre-yellow and brown hydrous iron oxide (limonite), and the felspar into white kaolin. The bases liberated in the process have been leached down by percolating rain, leaving the upper part of the profile more acidic (pH 6.0) than the lower part (pH 6.6). Chemical analysis shows that considerable amounts of silica have also been leached out of the upper soil. The resulting Yellow Earth contains about 45 per cent. of coarse sand (2.0 to 0.2 mm.), 25 per cent. of fine sand (0.2 to 0.02 mm.) and 30 per cent. of silt and clay. The silt-and-clay fraction consists chiefly of limonitic and kaolinitic decomposition products, while the sand comprises the still unaltered volcanic ash minerals.

(3) *Formation of Terras.*—Towards the bottom of the 6-foot profile, the sandy material is often found to be firmly cemented and hardened by silica, which has been carried down in solution as silicates. The reaction of the cemented material is usually alkaline (pH 7.4). In many places, the deeper-lying material has been completely sealed up by infiltered silica, producing a veined, pinkish-grey, harsh, gritty rock called locally "terras" (possibily a corruption of "trass") which is often used as road metal. The occurrence of this material at varying depths plays an important part in soil erosion. All along the Windward Main Road, from Kingstown to Georgetown, a distance of 20 miles, hardened grey terras may frequently be seen in the lower part of the roadside bank, sharply overlaid by Yellow Earth.

The development of a fluctuating water-table above an impervious terras bed gradually changes the appearance of the soil profile by causing the precipitation of iron compounds within a mottled layer immediately overlying the terras. Occasionally the water finds an outlet in surface

FIG. 1.—*Mt. Coke-Stubbs Village area.*—7th mile post, Windward Main Road. Badly eroded hillslope, 15°; peasants' land; planted in arrowroot, following groundnuts Note "erosion pavement" with incipient gullies and cliffed edge of cultivation. The soil is a stony, orange-tawny, speckled Yellow Earth. *Photo, C. K. R.*

FIG. 2.—*Ratho Mill area.*—4th mile post, Windward Main Road. Eroded and gullied hillslope, 10°; peasants' land; old cotton field. Note developing gully, old cotton banks, and small escarpment at top of field just below the clump of trees, marking limit of cultivation. The soil is Yellow Earth. *Photo, C. K. R.*

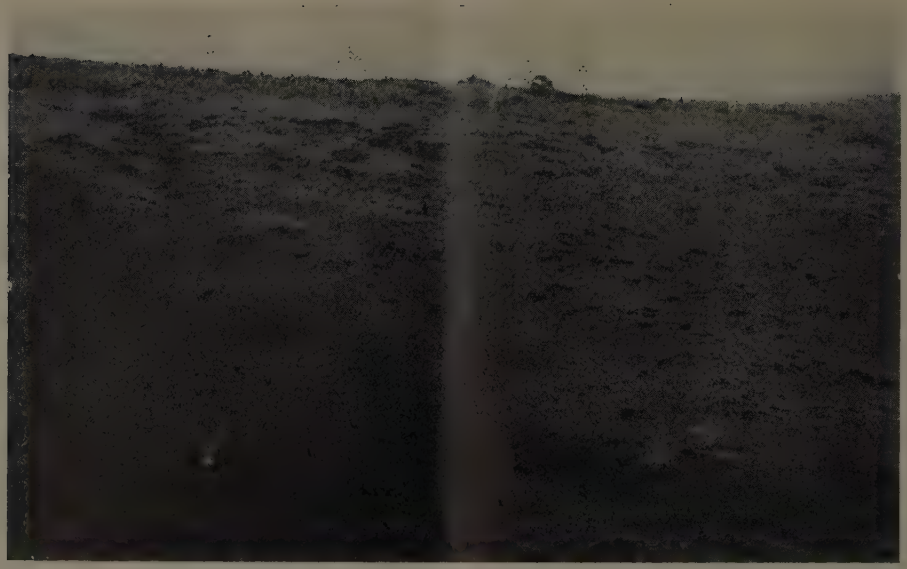

FIG. 3.—*Peruvian Vale Estate.*—11th mile post, Windward Main Road, Sheet-eroded hillslope, 15°; abandoned arrowroot field, cropped continuously for 15 years. Note almost entire absence of arrowroot plants and bare patches of stony Yellow Earth soil with shallow sod of grass and weeds. *Photo, C. K. R.*

FIG. 4.—*Peruvian Vale Estate.*—Near 11th mile post, Windward Main Road. Roadside section, 18 feet deep; Yellow Earth "hill-creep" soil, distinctly stratified, 5½ feet thick, overlying old basement rocks, comprising a much-decomposed lava-flow showing "onion weathering", covering grey cemented agglomerate (terras). *Photo, C. K. R.*

FIG. 5.—*Westwood Estate.*—2 miles south of Chateaubelair; Leeward District. Peasant Settlement. Eroded Valley-slopes, with gully in middle, partly reclaimed by vegetation. Note deforestation, except for small patch of trees at summit of conical hill, 800 feet elevation, 38° slope. Note also old cotton banks along contours of hill in right foreground, 36° slope, with road cut in side, and continuing round the valleys and spurs. *Photo, C. K. R.*

FIG. 6.—*Cumberland Estate.*—2¼ miles south of Chateaubelair, Leeward District, view of Westwood, looking south, showing rugged topography. Arrow-root fields with gully in middle distance; hillslope, 40°. *Photo, C. K. R.*

FIG. 7.—*Belair District.*—South Windward District. View from highest point of Dorsetshire Hills above Kingstown, looking east. Peasants' holdings with contour banks; Yellow Earth soil. Note gentle slope of skyline ridge, characteristic of windward mountain spurs, with indications of ancient marine terraces; hillrange above Vigie Road. *Photo, C. K. R.*

FIG. 8.—*Rutland Valley.*—Leeward District, 6 miles north of Kingstown, looking south-west from near Mt. Wynne. Layou Village in right back-ground. Typical leeward valley-compartment, enclosed by rugged hill-spurs. Note wall of columnar volcanic lava in west-trending spur, the talus slopes at the foot of the spur, and the valley flat planted in sugar-cane and coconut. *Photo, C. K. R.*

springs, but often it lies stagnant, inducing anaerobic conditions within the soil, which are very harmful to the root-systems of crop-plants (5). In extreme cases, the accumulation of water during continued heavy rains may produce plastic flow in the Yellow Earth overlying a terras bed, and extensive landslides, involving large tracts of country, may be initiated. Thus, between Colonarie and Black Point, the road cliff, 50 feet high, shows a thick layer of roughly-bedded Yellow Earth, the dips closely following the configuration of an old land surface. According to Anderson and Flett (6), the Yellow Earth here represents *hill-creep* material that has gravitated in a water-logged condition from the higher grounds at some remote period.

Another similar example is displayed in a new road section near the 11th mile post at Peruvian Vale. Here, an ancient basement agglomerate, altered by weathering to a hard granular terras is overlain by a spheroidally-jointed old lava flow, which in turn is covered unconformably by a layer, 5½ feet thick, of Yellow Earth. (*See* Figure 4 which clearly shows the sequence.) The marked bedding and alternation of hard and soft layers suggests successive stages of "hill creep", or a succession of old landslides.

(III) Evidence of Soil Erosion in St. Vincent.

There are five main kinds of soil erosion caused by water action, namely, (i) sheet erosion, (ii) rill-washing, finger or shoestring gullying, (iii) gully erosion, and (iv) land-slip. All these types are represented in St. Vincent in different degree.

(I) Sheet Erosion.

This is the commonest kind, and it is very prevalent in the arrowroot and cotton fields of the windward foothill belt, and in the southern leeward district where the most mature Yellow Earth Soil occurs. A good example is shown in Figure 3 illustrating an abandoned field at Peruvian Vale. This field shows a 15° slope, and has been continuously cropped to arrowroot for 15 to 20 years. Laboratory examination of surface 6-inch soil samples, collected in June, 1938, at the bottom and top of this particular field showed considerable differences in organic matter and nitrogen contents (O.M., 1.3 *v* 0.5 per cent.; total N, 0.07 *v* 0.03 per cent.), indicating that a large amount of surface humic soil had been washed downslope. Piles of surface black soil had collected in a gutter and along the roadside bordering the base of the field.

The losses of humic soil by surface washing in such cases must be very great. The main nutritional wastage concerns soil nitrogen. Although somewhat more plentiful in the humic soil, available phosphate and potash are not necessarily deficient in the subsurface soil exposed by erosion, because of the high content of fresh mineral grains in all parts of the profile. Applications of nitrogenous manures to lands worn out by sheet erosion have been found in St. Vincent rapidly to renew their fertility. Both organic and inorganic nitrogenous manures have given this result. Field experiments recently conducted by the Agricultural Department showed that sulphate of ammonia added alone gives increases in yield of the order of 21 to 57 per cent. of arrowroot rhizomes, 35 per cent. of seed cotton, and 20 per cent. of sugar-cane, on badly-eroded Yellow Earth hillslopes. Pen manure, cotton seed meal and vegetable mulches give similar responses, and it has been demonstrated that their effects are mainly due to their nitrogen component (7). Sheet-eroded areas may consequently be rapidly regenerated in St. Vincent by suitable tillage, supplemented by nitrogen manuring, but the indescriminate use of artificial nitrogenous substances, which offer a ready means of increasing crop production, should not be over-encouraged. Consideration should be given rather to their value when incorporated in soil conservation schemes involving the establishment of suitable soil-binding vegetation.

(2) Rill-Washing.

This usually succeeds sheet erosion, because of the tendency of runoff water to follow shallow depressions between individual crop plants, or to accentuate the natural irregularities of the land surface. The removal of spongy humic soil over areas where mature Yellow Earth occurs often lays bare a compact "erosion pavement", in which the harsh sandy material may already be partly cemented and so rendered impervious to water. Such a surface is particularly prone to finger-gullying, and rill-channels rapidly develop during rains into miniature river systems and ever-deepening gullies. Typical examples of the various stages in the sequence may be seen in cotton and arrowroot fields bordering the Windward Main Road, for instance, at Ratho Mill, Mt. Coke, Carapan, Mt. Pleasant, Peruvian Vale, Spring and Union Estates. Figure 1 illustrates a clear case of erosion pavement and incipient gullying occurring within a peasants' holding at Mt. Coke near Stubbs Village, on land planted in arrowroot following ground-nuts. Another somewhat different case is illustrated in Figure 2 showing the development of a single deep gully in an old cotton field on peasants' land at Ratho Mill. Numerous examples of rill-washing also occur in steeply-sloping fields bordering the narrow valleys that radiate from the central ridge within the windward region, for instance, at Carapan and Mt. Grennan. In all the cases examined by soil sampling and laboratory analysis, striking differences in organic matter and nitrogen contents were revealed between the soil at the top of the slope and the transported soil at the base. Generally the values for bottom soil were 1½ to 3 times as large as those for the soil near the crests (average values, O.M., 1.6 *v* 0.9 per cent.; N, 0.09 *v* 0.05 per cent.). The effect of scouring may clearly be seen when the hillslope fields are lying fallow, the black soil of the hollows standing out in great contrast to the brownish-yellow soil of the higher grounds.

(3) Gully Erosion.

In recent years, gullies have become conspicuous in certain parts of St. Vincent, particularly the outskirt of villages where the land has not been kept continuously cultivated. Thus, at Troumaka (a village near the coast midway in the leeward belt), a great gully, generally known as German Gutter, has developed since 1914, from the outlet of stormwater drain that was allowed to form a small waterfall. This has gouged out an ever-lengthening ravine by backward undercutting, though steps have recently been taken to limit its further growth by building retaining walls, and by allowing bush vegetation to establish itself. In certain peasants' holdings, gullies have been allowed to grow from rills and small water courses through failure to keep border-lands continuously cultivated.

Deep gullies develop particularly rapidly in compact boulder-free volcanic sand having great depth and uniform texture; such material occurs at German Gutter and at several other places in the north-leeward region of St. Vincent where the volcanic ejecta are comparatively young, and where cementation of the lower part of the profile has not sealed up the subsoil. In mature Yellow Earth soil, the development of gullies is usually limited by the presence of impervious terras at relatively shallow depths.

(4) Land-Slip.

The main conditions favouring land-slip are long-continued torrential rains, sloping land of considerable area, and a soil having restricted downward drainage, either because of the occurrence of a "hard pan", a cemented or impervious subsoil, or bed rock at a relatively great depth below the surface. The thick soil layer absorbs water to full capacity, so that the particles begin to separate; the whole sodden mass then shears away, either in blocks or bodily from its base, and gradually flows downhill under the pull of gravity. The resistance to shearing in coarse-grained sandy soils is provided solely by internal frictional forces, which quickly diminish as the mass becomes lubricated by waterlogging. In fine clays however resistance is provided by cohesion, part of which results from molecular adhesion forces, and part from capillary forces associated with the presence of water, and largely influenced by soil structure. The slip surface tends to have cylindrical sectional shape in the case of homogeneous materials, and movement generally consists in the rotation of large wedge-shaped masses of water-logged soil which may actually be projected outwards at the toe (8).* The occurrence of variable strata of bed rock complicates the process by introducing a depth factor, and the slip surface may exhibit a very complex form. The preventative effect of vegetation in binding together a loose soil may be appreciable, but instances sometimes arise where the steepness of the slope or excessive rains produce land-slides of such magnitude that the whole of the root-inhabited soil is involved, and large areas of forest or agricultural land are bodily displaced over considerable distances.*

The occurrence of land-slip in St. Vincent and in other parts of the West Indies is more frequent than is perhaps realised. Throughout the wet season, this form of soil erosion is constantly affecting clay and silt lands whose underground features, specific properties and structure favour waterlogging; it less frequently affects deep sandy soils whose downward drainage is unrestricted. Whether or no it has accounted for the field characters of the Yellow Earth soil of the windward foothill belt of St. Vincent (the so-called "hill-creep" soil) as postulated by Anderson and Flett, has not yet been finally decided on the evidence available. That land-slip is a highly destructive agent in hilly lands such as abound in Dominica, Grenada and St. Lucia, was amply demonstrated during the excessive rainfalls of November, 1938. Much valuable agricultural land and expensive earth-works and road embankments were damaged by land-slips during this period, and loss of life ensued through the destruction of houses. Regularly in the West Indies, erosion caused by land-slip removes or disturbs large quantities of fertile soil, especially over undulating clay country that has been denuded of all forest growths and planted in crops whose root systems do not bind sufficiently, as for example, the sugar-cane lands of the Naparima District of Trinidad.

(IV) Erosion Problems in St. Vincent.

While it is not possible at this juncture confidently to recommend methods for counteracting soil erosion in St. Vincent, a brief discussion of some of the problems may be of interest. Field experiments are soon to be initiated in different parts of the island by the Agricultural Department for the purpose of testing the applicability of certain of the well-known methods of soil conservation that are receiving extensive trial in the United States of America, and are fully described in the voluminous literature on the subject.

The problems of soil erosion in St. Vincent mainly concern two distinct types of land, namely, (A) relatively-recent Volcanic Ash land, where the soil-profile is scarcely developed, and (B) Yellow Earth land, where the soil displays a well-differentiated profile. In each case, the surface of the land is inclined at all angles up to 45 degrees,

* A case of such forcible ejection of a large mass of waterlogged soil occurred at Ravine Poisson, St. Lucia, in November, 1938, and was erroneously attributed to volcanic activity.

* An example of a large land-slide of this sort occurred some years ago on a steep hill-slope on the south-windward coast of Dominica, where several acres of a lime estate were displaced and fell into the valley after a cloudburst. Another large landslide occurred in 1933 on the western slope of St. George's Hill, Montserrat, also caused by a cloudburst, and the traces of many other land-slides that took place at the end of the last century, may be recognised on the hill-slopes above Soufriere Village, St. Lucia.

and is usually steep, though generally steeper in the Recent Ash than in the geologically-older and more extensively denuded Yellow Earth lands.

(A) Erosion in Recent Volcanic Ash Lands.

These comprise approximately one-half of St. Vincent, north of a line extending up the Cumberland Valley on the leeward side, across the Main Ridge, and down the Colonarie Valley on the windward side.* They thus include most of the Garu mountain and foothill country, as well as the whole of the Soufrière volcano. The recent ejecta from Soufrière partly filled in the deep depression lying between it and Morne Garu, but they reached no further south than Wallibu Village on the leeward coast and Georgetown on the windward.

In their account of Soufrière, Anderson and Flett (6) give a graphic description, illustrated by striking photographs, of the intense geological erosion (or surface denudation) that affected the volcanic deposits during the rainy season following the latest eruptions. The thickness of the fresh accumulations varied from 50 to 80 feet and occasionally 200 feet in the broad radial valleys, and from one to 5 feet on the level lands, though mainly less than one foot on the steeper slopes. Within a few days, torrential rains had carved terraced ravines 20 to 30 feet deep in the valley deposits, and streams of thick mud had invaded the lower ground. Large boulders had become dislodged from the slopes and had rolled down into the valleys, and vast masses of sand had been carried far out to sea, leaving much of the coarser materials on the slopes. The extent of removal was proportional to the steepness of the gradient, but the only final conspicuous change in the topography was the widening of the crater and the partial infilling of the old valleys.

As has already been stated, retardation of erosion and stabilisation of the new land surface were eventually brought about through the natural agency of vegetation. Since the latest eruptions, the re-afforested slopes of the Soufrière mountain have not been utilised for agriculture, except the lower windward slopes where a large coconut estate (Orange Hill) has been developed, and the flat coastal lands of the devastated Carib Country, where an extensive sugar-cane estate (Mt. Bentinct) has been re-established. Further south, however, the steeply-sloping lands of the Garu mountain mass, comprising somewhat older Recent Volcanic Ash, have long since been under cultivation to cotton and arrowroot. The main agricultural areas occur in the north-leeward district around Chateaubelair (Richmond Vale) and north and east of Wallilabou (Cumberland Valley; Westwood and Rose Hall Land Settlement), and in the windward uplands (Three Rivers Land Settlement). The kind of topography and the general state of the land surface in the Cumberland area are illustrated in Figs. 5 and 6. Above the 600-foot contour, the hill-crests and spurs are here mostly covered with tropical rain forest, although in certain instances the hills unfortunately have been cleared of trees right to their summits. The cappings of forest-growths, where they exist, have doubtless saved the cultivated lower slopes from serious erosion by regulating the entry of water into the soil, while the deeply porous nature of the parent material and the absence of cementation have prevented the development of surface runnels, except during the heaviest rainfalls. Thus soil erosion in the northern part of St. Vincent at the present time is generally not profound nor conspicuous, though it may attain appreciable magnitude during sudden storms, when large amounts of soil are washed off the slopes, just as happened immediately after the eruptions.

The only method practised on Recent Volcanic Ash lands for conserving the soil is the construction of contour-ridges, upon which rows of cotton seed are sown during September wet weather, but the banks are occasionally broached in very heavy rains by the accumulation of water behind them. This may then start a series of small gullies that may eventually cause serious damage to lands lower down the slope, not necessarily owned by the peasant on whose holding the damage originated. Some alleviation from the trouble might be gained if the banks could be stabilised by suitable vegetation, and provision made for rapid removal of the water in the troughs by a system of ramifying or "herring-bone" surface drains, designed on a broad plan so as to embrace the whole of a hill-slope or a topographical unit of area.

For the purpose of diminishing soil losses on the steep slopes through surface washing during heavy rains, the object should be not merely to bank up the soil behind longitudinal barriers, nor to build it up into broad terraces, but rather *to allow the water to run away without impedence, while greatly reducing its flow over the soil surface.* This may best be effected by establishing a grass-sod with species having a low-growing or "mat" habit. The grass roots will bind together the grains of loose volcanic sand, but the prostrate leaves will not hinder the water from flowing away. The same result might be achieved by laying down rows of small boulders at frequent intervals along the contours, but the stones should not protrude more than a few inches above ground-level otherwise they will retard the rapid run-off of storm water. For the purpose of temporarily stabilising a steep slope until a cover of root-binding plants has become established, rows of bamboo stems or tree-poles might be substituted for stones where easily procurable. Boulders are plentiful in the volcanic ejecta of the northern part of St. Vincent, and bamboo, if not naturally abundant, might easily be grown in clumps at convenient places. Other methods deserving trial are the establishment of strips of natural grass vegetation planted along the contours, alternating with strips of cultivated soil, or the establishment of a *uniform* grass cover over the whole of the slope,

* This division is clearly depicted on the old Admiralty Map of St. Vincent, issued in 1890.

with shallow holes excavated in it at regular intervals for the planting of the crop. On some of the gentler slopes where the soil is particularly porous, broad terraces, constructed behind low barriers of bamboo-palisade, might prove satisfactory, or even rows of living shrubs (including bushy crop-plants such as Pigeon Pea), or tall clumps of grass (such as Guatemala Grass or Cus-Cus Grass), although in this case there would always be a risk of waterlogging and broaching where the soil is not sufficiently open in texture to cope with the heaviest of rainfalls.

The prevalence of boulders and rounded stones of all sizes among the deposits of Recent Volcanic Ash occurring in the northern half of St. Vincent in itself is a very favourable feature, in that the larger fragments help to stabilise the slopes and to prevent the formation of gullies. In certain localities, however, boulders and stones are less plentiful, and there erosion gullies readily develop, as at German Gutter near Troumaka. In general, boulders appear to be more abundant on the leeward side of St. Vincent than on the windward, a characteristic feature of certain other West Indian volcanic islands, notably St. Kitts.

(B) Erosion in Yellow Earth Lands.

The hilly-land soils of the southern half of St. Vincent, being very much more mature than those of the northern half, exhibit somewhat different erosion phenomena, and present other problems of soil conservation. The chief physical features that differentiate them from the Recent Ash soils are (*a*) the occurrence of a more-or-less cemented subsoil at varying depth below ground-level, (*b*) their variable but usually greater imperviousness to water, (*c*) their lesser degree of stoniness, and (*d*) their greater content of humus. Instead of rain water soaking rapidly and deeply into the soil, as is the case in typical Recent Ash soil, downward percolation is prevented or restricted in the Yellow Earth either by a cemented bed of terras, or by the closeness of texture of the upper layers, caused partly by the admixture of clayey residua derived by the weathering of the parent mineral grains. Various combinations of these circumstances appear to decide the kind and degree of erosion that may be manifest in particular instances. Thus, in new lands recently brought into agricultural production from forest, the occurrence of a large amount of humus in the surface soil may protect the land from rapid erosion because of the well-known tendency of humic soil to form water-stable crumb. In due course, however, such lands deteriorate through continued cultivation (particularly when planted in arrowroot), the crumbiness gradually disappearing as the humus is wasted by oxidation, and as the natural soil structure is destroyed through mechanical disruption by tillage. Eventually, a single-grain mineral structure is imparted to the soil; this greatly favours sheet-erosion because of the fact that single soil particles readily float apart when wetted, those lying near the surface being lifted bodily into the water-stream and rapidly removed. Erosion of this kind is especially prevalent in uniform fine-sandy soil whose component particles range in size around 0.1 mm. diameter (9). Unfortunately, this textural type is rather common in the Yellow Earth lands comprising the southern windward belt of St. Vincent, where sheet erosion is consequently conspicuous.

The most promising means of combating sheet erosion induced by soil-degeneration into a single-grain structure and by restricted downward drainage would seem to be the provision of strips of low-growing grassy vegetation between alternating rows or strips of the cultivated crop. Terracing, for reasons already considered, would probably not prove to be satisfactory in those cases where the suface soil layers rapidly "fill up" during rains, while tall barriers of woody plants or tussocky grasses would merely impede the run-off and encourage waterlogging. In certain instances, a system of crop rotation involving a grass-ley might prove very suitable, particularly in those peasants' settlements where stock-raising has been accepted as an integral part of the farming system. The scheme seems worthy of extended trial in any renewed attempt to solve the land settlement problem in St. Vincent. In order to overcome the need for increasing the size of the individual holdings, necessitating the migration of a part of the peasant population to some other area, the land planted in crops would have to be more intensively cultivated so as to balance the diminution of area of productive soil caused by the establishment of the grass strips. In this event, the application of home-produced pen manure augmented by imported artificial ferttilizers (certain of which have recently been proved to be capable of greatly increasing the yield of crops customarily grown in St. Vincent), would aid very materially, as proved to be the case in the resettlement of eroded farm lands in the Tennessee Valley under the aegis of the new Authority.

In lands where arrowroot is grown as the main crop, the proper employment of artificial nitrogenous manures should enable the planter to procure a rapid land cover. The immediate abandonment of arrowroot fields that begin to show signs of diminution in yield and their replanting in some other close-growing crop, or preferably, the substitution of a grass-ley for the purpose of rejuvenation, would help to conserve the surface soil of Yellow Earth arrowroot fields prone to sheet erosion, and would provide humus and grass roots as binding agents for the fine sandy soil material.

The prevention of "hill-creep" which results from the thorough saturation by water during periods of long-continued heavy rains, of Yellow Earth soils underlain by impervious terras, would seem to be mainly a question of the provision of adequate drainage. Areas subject to this form of damage, such as the gently-sloping lands that comprise the broad marine terraces of the southern windward district of St. Vincent, should be treated as single topographical units, and plans formulated for

each according to its characteristic features. To quote the Chief of the United States Soil Conservation Service (10) "It is at once evident "that individual efforts to control erosion are "likely to be ineffective. They can be costly and "can never be anything but piecemeal. The one "system of attack on erosion that promises "success is the co-operative attack, beginning "where erosion begins, at the crests of ridges, and "working down, farm by farm and field by field; "to the stream banks in the valleys below".

Acknowledgment.

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OBITUARY.

Arthur William Knapp.

THE death of Arthur W. Knapp on 6th January, at the early age of 58, removes a figure of international reputation from the Cocoa and Chocolate industry.

A Birmingham man, Knapp was educated at King Edward's Grammar School, Aston, and at Birmingham University. He graduated B.Sc. of Birmingham and London in 1901, and M.Sc., Birmingham, in 1928. In 1903 he passed the examination for the Associateship of the Institute of Chemistry, becoming a Fellow in 1906. He was also a member of the Institute of Chemical Engineering.

He held appointments in Public Analysts' Departments in London, where he did work for Mr. (now Sir) George Newman, in Belfast and in Birmingham, and in the Research Laboratory of Messrs. Lever Bros. Ltd. In 1911 he became Research Chemist to Messrs. Cadbury Brothers Ltd., Bourneville, and in 1923, Chief Chemist.

While occupying the latter posts he carried out much research work of great importance to the industry as a whole, was the author of standard works on cocoa and chocolate, and of numerous scientific papers published in British and foreign technical journals. His knowledge of the problems of the cultivation and fermentation of cacao made him an authority whose views were sought by growers and manufacturers in many parts of the world, and gained for him in 1935 the Médaille de Mérite de l'Office Internationale du Cacao et du Chocolat. He paid several visits to the West Indies and West Africa where he made many friends and did much to establish the happy relations that now exist between his firm and Government Departments of Agriculture in these colonies.

He held a high place in his own profession, having served on the Councils of the Institute of Chemistry, the Society of Chemical Industry, the British Association of Chemists (of the Local Sections of all of which he had been Chairman), the Society of Public Analysts, and of the Midland Chemists' Committee, of which also he had been Chairman. He was also a member of other scientific bodies. In the summer of 1938 he attended the Annual Meeting of the Society of Chemical Industry in Canada.

His labours on behalf of his fellow chemists were unremitting. Besides his so widely recognised scientific attainments, Mr. Knapp was endowed with considerable artistic sensibilities and literary skill. His non-scientific writings included an essay on Nietzsche, the German philosopher, two or three plays, and humorous and critical contributions to various journals. He was a member of the Fabian Society.

One of his colleagues writes:—"His energy, courage, enthusiasm, and skill, in every work to which he set his hand, were unbounded, and his devotion to his work, to his profession, and to the interests of his brother chemists, particularly to those less fortunate, may well serve as an example to all".

He is mourned not only by his family and by his Bourneville colleagues, but by very many friends in scientific circles in the Midlands and other parts of this country, on the Continent, in America in West Africa and the British West Indies.

FURTHER STUDIES IN TROPICAL LAND TENURE.

By H. M. Leake.

(*Concluded from Tropical Agriculture*, Vol. XVI, No. 2, p. 38.)

IX. SUMMARY.—*Concluded.*

The preceding remarks apply more particularly to the case of a land tenure system based on peasant holdings. The reaction to the period of depression covered by this series of studies would appear to be, under this system of tenure, an intensification of official control of the methods of production with the direct object of retention of markets through the development of quality in the produce. The argument advanced in this summary is that this road to the immediate objective cannot lead to the oft repeated ultimate objective of a people capable of standing by itself. It remains to trace the reaction of that other major system of production, the plantation working with paid labour.

This system, particularly in its corporate form, the Company owned plantation, is in a better position to supply the requirements of capital and technique even if the opportunity has not always been seized to the full. The most complete developments along these lines are to be found outside the Empire in the Hawaiian and Javan sugar industries. Here the industry itself organizes and controls the technical staff and carries the cost. Some measure of the potential benefit of a technical service so organised is given by the fact that these two countries lead the world in the production of cane per acre while the former country has doubled this yield within a period of ten years. In the Empire reliance has tended to be placed on technical services less directly associated with the industry, with the cost borne only in part by the industry itself. The relative efficiency of the two methods cannot be discussed here; conclusive proof would be difficult to obtain. The evidence suggests, however, that greater efficiency lies with the technical services fully incorporated within the industry.

The major effect of the depression on the plantation industry has been paradoxical though natural. Characteristic of it was (and is) overproduction, better expresed perhaps as oversaturation of the markets, to an extent which, in some cases, has necessitated international control. In these, as in other businesses, the charges are divisible into overheads which vary little with the scale of production, and actual production costs. Overheads, thus, being to a large extent fixed, a direct effort is made to reduce production costs and, since labour forms the major item in these, it is here that the biggest potentialities for saving lie. This reduction in the labour bill can be effected in three ways; by actual contraction of the labour force employed with its concomitant, a reduction in the standard of cultivation—typified by the cacao industry of Trinidad—a reduction in the scale of wages, or replacement of labour by mechanisation, an actual increase in the overheads through the capital cost of the implements, but one the interest on which plus the running costs show a saving on the cost of the displaced labour. Such a development is seen in its intensest form again outside the Empire, in Hawaii. But there is also an indirect effect. Since the cultivation costs are largely independent of yield, there is an urge to attain high yields. Part of the savings which can thus be effected will be spent on additional measures, manures and so on, which lead to that end, and part on less direct measures for the same end, the employment of technical advisers. These measures, in practical experience, have been found to lead to more economic production and herein lies the paradox of the response for the demand for reduced production taking the form of greatly increased potential supplies, an effect well seen both in the case of sugar and rubber. In the result there arises the problem of a growing area of land passing out of cultivation.

These, however, are problems for the capitalistic element of the industry. The present more important aspect is that of the reflexes affecting labour. Labour under such conditions is exposed to two largely antagonistic influences. On the one hand the spread of education and the free dissemination of news has created a consciousness of the existence of standards of living superior to those to which labour has been accustomed, and stirred a desire to share that higher standard; on the other, a reduction of wages and even unemployment make realization of that desire appear more remote than ever. In recent history of many of the Colonies the result of these influences is writ large. In Trinidad, Jamaica, Barbados, British Guiana and Mauritius riots have resulted and a commission is now investigating the problems raised thereby in the West Indies. The matter cannot, therefore, be dealt with here except to say that whatever the proximate cause, the unrest could not have spread as it did if there had not been a widespread underlying discontent among the agricultural labouring community which forms the mass of the population. It is, further, significant that the unrest assumed major proportions in those territories where agricultural labour was largely dissociated from the land and dependent on purchased, and often imported food supplies. That this condition is generally associated with the most highly organized of the tropical agricultural industries, the sugar industry, is incidental. It is in the form of organization and not in the particular industry that the causes lie. Labour which has not, as here, any alternative means of earning a livelihood must, perforce, accept the terms of employment offered. These are conditions characteristic of slavery though imposed under the guise of freedom. If proof of

this is desired it will be found in a comparison between such labour and that of the plantations in the East. In these latter, the labourer retains contact with his home village and finds his safety valve in his ability to return home if the conditions imposed become too onerous.

As this brief discussion of the question indicates, the plantation industry is, in many respects, the antithesis of the peasant system. While it can provide both the capital and technical requirements of modern agricultural production, it fails to provide the human requirements. This reverses the position of the peasant system for this, designed to meet the human requirements, fails to provide the two prerequisites, capital and technical control.

The plantation and peasant systems have been discussed above as independent entities. The former, however, is no where found in undisputed sway except, perhaps, in the demarcated areas of East Africa. Elsewhere, where a plantation system has developed, there exists side by side and intermingled with it a peasant system which may be independent, except in as far as it provides a source of labour, but may be interlinked. Examples of this latter are the cane farming communities of the West Indies and Mauritius. As this 'farming' system has developed, it offers little prospect of supplying the human requirements. A review of the history of the cane farming system in Trinidad, where it was first introduced as a definite policy, shows that it was based on an antipathy, instead of a community of interests. Though a considerable advance has been made with the introduction of a sliding scale for the determination of the rate of payment for cane, the basic antipathy remains and is disclosed by the fact that the scale is imposed by the legislature and not by the free action of the parties concerned. The advances made by the plantations, it is true, bring capital requirements within the orbit of the system but, as the relatively low yields obtained by cane farmers both in Trinidad and Mauritius indicate, the technical requirements are not met. Labour, as represented by the cane farmer, is not in a position to satisfy its new-born desires and, under the adverse conditions of the past few years, offers a fertile soil for discontent to blossom into unrest. The proximate cause of the disturbances in Mauritius was the question of the scale of payment to cane farmers.

Yet if real progress is to be made towards the goal, some method must be found which provides equally the human and the plant requirements. If the range of territories covered by these studies is surveyed, two stand out in marked contrast to the rest. Fiji's primary product is sugar derived from the cane and the cane sugar industry has suffered as severe a depression as any other in recent years. Yet the Fijian industry, starting from a period of intense labour shortage and discontent, has built up a contented labour force and given adequate return on the capital investment while selling its product in the depressed free market. In the Sudan, in spite of the low prices realized for its staple product, cotton, prices far below those estimated when the scheme was launched, has achieved the same end as the eagerness with which tenures are sought when any extension of area in the Gezira has been undertaken.* These experiences are in such marked contrast to experience elsewhere that they call loud for explanation.

What, then, is the key to their success? This lies in a superior organisation large enough to give the stability which attracts capital sufficient to meet all needs including the technical requirements of each plant according to its kind both during growth and processing of the produce, and an inferior organization of a peasantry, with the two organizations linked by a community of interests. The linking agency is the technical service, trained to act as guide, philosopher and friend of the peasants and thus ensuring that the requirements of the plant up to the stage when the produce passes to be processed, are duly met. Yield, the primary objective of cultural operations, is so guaranteed as far as nature permits while the centralization of processing ensures quality, and the size of the organization provides the conditions for successful marketing. That even yield can be attained by the peasantry under this system is proved by the example of Fiji where, in marked contrast to Mauritius, the yields of the peasant approximate to those obtained on the small areas retained under centralized control, that control over disease is obtainable is proved by the example of the Sudan, where leaf-curl, once a threat to the entire industry became negligible by 1934.† In view of these experiences it is curious to find a general antipathy to the system and opposition to its adoption elsewhere. The reasons for this antipathy are diverse. Partly they find their origin in history. There is a certain superficial resemblance between such a Corporation and the old Chartered Companies which is sufficiently close to create prejudice. Sir Archibald Weigall gave expression to this point of view when speaking to the address by Sir Edward Grigg.‡ The territory is visualised as apportioned into a number of large spheres of influence in which the population will be subordinated to a capitalistic organization concerned primarily with its own financial ends. It need hardly be said that this is a travesty of the actual situation. In the days of the Chartered Companies land was the sole security which could be offered capital and this is no longer the case, as the Sudan example shows. Government controls the terms of the concession and, in doing so, serves a truer function than when it acts as direct organizer of production. Its drift to monopoly when it does so is well shown in the course of these studies; and it is a monopoly against which the primary producer has no appeal.

* *See* particularly Chairman's speech, Kassala Cotton Co., 1929; *The Times*, 17 May, 1929.

† Chairman's speech, Sudan Plantations Syndicate, 1934.

‡ *United Empire*, 23 (1932), p. 27.

Nor is the immediate establishment of a number of spheres of influence completely covering the country a true presentation of the picture. The area of full control of one unit will vary in extent with the nature of the particular product and be determined by the area required to yield at least the minimum amount of produce for economic handling. The system can well be left to find its own economic balance in the general agricultural organization of the country. It has, moreover, this advantage, that it can be tried out experimentally by the establishment of a few units, and the natural location of such experiments would be in those territories where economic depression is most severe and, particularly, where no alternative means of procuring subsistence exists other than a paid wage on plantations.

An objection of a different nature comes from another quarter; the technical officers and those responsible for their training. There is a security about a large, official technical service scattered through the Empire which appeals to the former and a simplicity in education which is attractive to the latter. But an extensive service carrying the security of Government employment inevitably entrenches itself behind prerogatives and, in time, loses much of its efficiency; too much for the exercise of the necessary business acumen. It is unnecessary to labour the point; the trammels of red tape are a by-word and this is the invariable reaction of human nature. Security and high emoluments rarely run in harness together and to members of the trained staff of a Corporation as here visualized there will be openings for advancement such as no Government service could offer, while the demand would become many times greater. Some indication of this demand is given by experience in the Sudan where each inspector is in charge of an area of cultivation of some 12 sq. miles. If even only the higher ranks of the Inspectorate be fully trained, there lies here, and in the staffs of the associated experimental and research organizations, a field of employment capable of absorbing the full output of the technical institutions.

It remains only to explain how such a system could be introduced. Clearly the method must vary according to the pre-established system in each particular territory; for the very divergent organizations of a plantation and a peasant system require different, but converging roads. The plainer road is that which leads from the plantation. Here much of the required capital is already invested in the industry and technical supervision, where now inadequate, can be readily fitted in to the present organizations. The Fijian procedure would be followed in the division of the cultivated area, except for a few experimental areas retained, into family holdings which will be leased to a tenantry. The area and terms of the tenure will be important. Area must be of a size which a family unit can reasonably cultivate and the terms of the tenure such that, while a portion of the area is laid down to the particular crop to be grown under supervision, the remainder will be at the free disposal of the tenant to raise home and subsidiary produce such as truck crops. Where the prevalent system of cultivation or the demand for dairy produce necessitates the keeping of cattle, common grazing may also have to be provided under the tenure; and, where possible, more than one product capable of being handled centrally should be raised. The terms of payment for the produce taken over will also be included in the tenancy agreement; ideally these should be on a share basis, as is the case in the Sudan, subject to a minimum as in the case of the Trinidad cane farming contract, but Fijian experience indicates that this is not essential to success.

It may, and probably will, be found that, as the result of the division of the plantation into family units on the above basis, the area under crop is inadequate to give the minimum turnover required for the economic working of the processing plant, and that an extension of area is necessary. Such a problem arose in the Sudan Gezira as the result of the substitution of a four, for a three, year rotation and it was solved by an extension of the concession area. Such a solution may not be so readily adopted in the more densely populated tracts and the problem is one which will have to be solved by a consideration of the facts of each particular case. The point is raised here primarily because it illustrates a much better method of solving problems like those of Jamaica than the land settlement schemes so widely advocated. There would be a stability about settlements woven into the economic structure which independent settlements could not attain.*

The road leading from a purely peasant system such as exists in West Africa is not so easy. Here there is not the basic area of land already in the possession of a centralised organization and under plantation cultivation nor, in general, has individual tenure become a recognized institution. Here Government must stand as guarantor of the necessary capital and the Corporation will erect the required processing plant and enter into agreements with the tribal representatives for the growth of the minimum of the particular crop, as before, under all necessary supervision. The details of such agreements cannot be discussed here. They will vary with each individual case and be subject to approval by Government. Experience will dictate the most satisfactory terms, the most essential of which will be the prevention of too great encroachment on home production. No insuperable difficulties need be anticipated in the drafting of such agreements for, under the mediation of Government, a working scheme has been evolved in the Sudan where the need for irrigation and the consequent recasting of all boundaries introduced complications unlikely to be met with elsewhere.

* H. M. Leake, Labour and the Sugar Industry, *Int. Sugar Jl.*, 40 (1938), p. 333.

It has been objected in this latter case that the system introduces monopoly and that is partially true. But it is a controlled monopoly with an impartial arbiter in Government and with opportunity of periodic revision when the agreements fall due for reconsideration. It is objected, too, as limitation of the freedom of the individual to grow what he thinks will pay him best. Restrictions of some sort are, however, essential for successful production. It is, therefore, less a question of restriction than of the best agency for enforcing the necessary restrictions. It can hardly be doubted that the enforcement of restrictions by a controlled agency will be less onerous than when these are enforced directly by Government as represented by the Agricultural Departments. In the former case there is a court of appeal; in the latter none. The evidence contained in these studies proves only too well the degree to which arbitrary restrictions come to be enforced in the enthusiasm of the Departments to achieve their aim.

Further evidence on this question of monopoly is provided by the recently issued Report of the Commission on the Marketing of West African Cocoa*. This Report has appeared while this summary was in preparation and too late to be discussed in the earlier account of those territories. It is the report of a Commission appointed to deal with the situation which had arisen from the hold up of cocoa as the result of buying agreements entered into between the buying houses and interpreted by the producers as the creation of a buying monopoly detrimental to their interests. The recommendations of the Commission include the establishment of a Cocoa Farmers' Association which would, in the words of *The Times*, "replace a buyers" semi-monopoly by an "inevitably far more complete sellers" monopoly."†

The situation cannot be dealt with in detail here. Briefly, the recommendations may be considered as a valiant attempt to provide a solution to the problem within the terms of the reference—to examine and report on the *marketing* of cocoa in the Gold Coast and Nigeria. The Commission has been compelled by the limitation conveyed by the word 'marketing' to swing from one monopolistic extreme to the other. The Report mentions, but offers no remedy for, the defective agricultural conditions under which cocoa is grown. A permanence of antagonism between producing and marketing interest is accepted as inevitable. Wider terms of reference would have opened a road for the reconciliation of that antagonism and the establishment in its place of a community of interests and a remedy of the cultural deficiencies.

The organization through Corporations here described is capable, as other organizations are not, of providing the three requirements seen to be necessary for the full development of the agricultural wealth of the country; capital and technical supervision, essential if the plant is to yield its full response, and human needs. That this is true of the first two is obvious; the last requires, perhaps, amplification. The experience of both Fiji and the Sudan is adequate proof that labour, under the conditions provided by the system, can satisfy both its material and psychological needs for a contented life. But mere contentment among the working population under a super-structure of finance and technical control in alien hands, while it is a solution of the immediate problem of many of the territories, is but a small step in the direction of the goal, a people capable of standing by themselves. For this purpose a section of the people must be educated to play their part, not merely in the political and administrative spheres, but in all those activities, production, trade and finance, which go to make up the life of a self-reliant community; and, in a country where agriculture is the dominant source of wealth, it is in agriculture that the outlet must be sought. The present systems offer few such outlets; these have to be sought in the various ranks of officialdom and the legal profession. Not the least of the advantages of the agricultural system now under discussion is that it offers this opening through infiltration, of the administrative and technical services and in the shares of the Corporation, it provides a new outlet for the accumulating wealth of the people. There is here provided a true road towards the ultimate goal. The road may be short or it may be long; the goal may never be reached if the required intelligence is not innate in the peoples. But at least the trust of leadership will have been fulfilled by the offer of the open road.

The history of the industrial development of India, initiated by British finance and technical skill and gradually passing under the control of Indians, illustrates this road, and it can hardly be doubted that the existence of a section of the community with the material stake in the country attained by following that road, has been one of the most potent stabilizing forces during the transition stage through which India has been passing. It is India's misfortune that she has not followed, in agriculture, the same road. Indian agriculture and its tenure systems has, in consequence, become the sport of politics.

In the territories considered in these studies it is agriculture that will, for long dominate. In agriculture must be sought the stabilising forces. It is the system of land tenure which directs those forces and it is in its early stages that direction is given to that system. Herein lies the importance of the subject of land tenure.

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* Cmd. 5845 (1938).

† *The Times*, Oct. 25, 1938.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Phosphate-deficiency Symptoms in Sugar-cane.—*By M. Kenjo.*

Using the variety P.O.J. 2725, the following symptoms of phosphorus deficiency were noted: growth was normal up to six weeks after germination, when retardation set in. No tillers were formed; the older leaves became yellowish-brown and commenced to dry at the tips; elongation of the roots was much stimulated, at least in the early stages, and their colour was decidedly reddish-brown. The length and the width of the leaves were much decreased, the decrease in the width being the most noticeable; that is, the leaves of phosphorus-deficient canes are narrower in proportion to their length. The internodes were shorter and thinner. The whole plant was stunted, but the ratio of root-weight to the weight of stalks and leaves was greater in phosphorus-deficient than in normally grown plants. Sucrose percentage was slightly decreased, but not so markedly as in the case of potash deficiency, and the accumulation of sucrose was not so marked as in the case of nitrogen deficiency. The percentage of reducing sugar in the juice was less than in the control plants.—(*Facts about Sugar*, Vol. 33, No. 12, p. 38, 1938.)

* * *

POJ 2961, A New Cane Variety from Java.—*By A. Caminha Jr.*

The variety POJ 2961 was first obtained in 1926 and in many respects is considered distinctly superior to POJ 2878, although to date it has received far less publicity. It is a nobilization of the Glagah and Kassoer "bloods"; its ancestry is given on a chart in the original paper. This chart shows a fourth nobilization of Glagah and the "bloods" of POJ 100, POJ 2364 and EK 28 figure prominently.

POJ 2961 is described as a tall cane of a green colour that changes to yellowish green and yellow as maturity is approached. The stalks are erect and well covered with wax; the leaves are a light green in colour. In general appearance the cane resembles POJ 2878, although the joints are shorter and are mildly barrel-shaped. It is said to be more resistant to pests than POJ 2878 and to yield about 30 per cent. more sugar. In 1935 it already occupied about a third of the total Java cane acreage.—(*Int. Sugar Jr.*, Vol. XL, No. 480, pp. 475-76, 1938.)

* * *

New Possibilities of the Two Boiling System.—*By A. L. Webre.*

In this paper, the author points out an interesting variation of the two boiling system for raw sugar massecuite. His idea is to eliminate the "B" or second strike from the three boiling system, leaving only the "A" strike and the "C" strike, both of substantially the same purity as originally. This is accomplished by starting the "C" strike with a footing of first molasses which is seeded with finely powdered sugar, preferably derived from breaking up large crystals, thus giving a strike of approximately the same purity as the molasses used. The successful operation of this process makes all of the commercial sugar out of the same purity strike, the "A" strike, and should, therefore, give a product of better quality with less trouble and complication than the three boiling system.

The success of this process depends greatly upon accurate control of all elements of operation in addition to the use of effective mechanical circulation.—(*Facts about Sugar*, Vol. 34, No. 1, p. 39, 1939.)

* * *

Alcohol from Molasses in India.

The Committee, appointed in January by the United Provinces and Bihar Governments in India to devise ways and means of starting the manufacture of power alcohol from molasses, has submitted its report to the Governments of the United Provinces and Bihar. It has concluded that power alcohol can be manufactured economically from molasses in these areas, that it can be marketed at substantially the same price at which gasoline is now being sold, and that an excise duty, even equal to that levied on indigenous gasoline, can be levied on it. The committee has recommended that the power alcohol industry should be established under the control of provincial governments and has suggested the formation of a Power Alcohol Advisory Board.

The committee also recommends the utilization of molasses in other directions—namely, cattle food, manufacture of fertilizers, and reclamation of fallow soils.

The development of this industry should eliminate the expenditure of large sums of money on the importation of 106,000,000 gallons of gasoline.—(*Ind. and Eng. Chem., News Edit.*, Vol. 16, No. 19, p. 529, 1938.)

* * *

Soaking Seed Cane Pieces.—*By N. J. King.*

The subject of soaking pieces of seed cane prior to planting, with or without addition of lime, magnesium sulphate and other compounds, has received considerable study in various countries. Results have been somewhat contradictory, depending on the condition of the soil and of the cane itself.

An experiment conducted by the author shows that an advantage is gained by soaking even seed pieces cut during rainy weather when the plants are succulent, and the soil of the field to be planted is well moistened. In this experiment the soaked seed pieces promptly germinated and more substantial growth before the shoots from the unsoaked pieces appeared above the ground. However, the unsoaked pieces did germinate ultimately, and gave just as good a stand as the soaked pieces. The advantage is that the soaked section got away to a good start and maintained its lead.—(*Int. Sugar Jr.* Vol. XL, No. 480, p. 476, 1938.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Recent Work on Cacao Fermentation.

In recent investigations on cacao, Dr. O. von Lilienfeld-Toal employed two relatively simple methods, one designed to follow the course of cacao fermentation, the other to determine the extent to which any particular cacao sample has been fermented. In order to follow the course of fermentation, the author determined, during the fermentation process, the "Permanganate Number" of the beans (which furnishes an indication of their tannin contents), by titration of acidified aqueous extracts with potassium permanganate. To determine whether or not a sample of cacao had been well fermented, a representative number of beans were separately tested for Cacao-Red by observing the colour changes on acidification of an aqueous extract. Both methods (which may be carried out on a single bean) were employed in the investigation of several types of cacao.

Application of these methods showed that Cacao-Red has usually disappeared completely by the eighth day of fermentation, and that by this time also the Permanganate Number has usually reached a minimum. Lilienfeld-Toal considers that fermentation carried out in excess of this period is detrimental to the quality of the resulting product, owing to further changes in the aromatic and flavouring substances present in the beans. Cacao may thus be excessively, as well as insufficiently, fermented. The correct stage at which to stop the fermentation is believed to be determinable by the methods described by the author.

Since the percentage composition of the bean varies only slightly on fermentation by comparison with the changes that occur in germinated or unfermented cacao when enzyme activity within the bean increases, Lilienfeld-Toal concludes that the process of fermentation should be considered rather as one of preservation, since it inhibits, rather than enhances, the activity of the enzymes contained in the bean.—(*Office Inter. du Cacao et du Choc.*, Vol. VIII, No. 9, pp. 331–58, 1938.)

* * *

A New Synthetic Fibre.

A new synthetic fibre has been made by the E.I. du Pont de Nemours and Company from coal, water and air, having the strength of steel and the fineness and beauty of silk. The new fibre is expected to rival natural silk in the hosiery trade and is made from a material known as "Nylon". It is basically different from rayon, in that it does not require cellulose for its production. The new fibre is the work of many chemists, but patents for its production are in the name of the late Dr. W. H. Carothers, du Pont chemist. Chemically, the Nylon fibres are polyamides. Like natural silk, they have a protein-like structure. Filaments finer than silk or rayon can be spun. The filaments have high elastic recovery and great strength. These properties together with the ability of the fibres to take common dyes easily render them suitable for the manufacture of two-thread hosiery having the wearing characteristics of the four-thread, service weight variety.

Besides hosiery, the new Nylon fibre may be employed for making a variety of products such as brush bristles, racquet strings, fishing lines, woven dress goods, velvets, knitted and woven underwear. It can also be employed as a transparent wrapping film, for plastic compositions, textile finishing agents and coated fabrics. Toothbrushes with the synthetic bristles are already on the market. The construction of an $8,000,000 plant at Seaford, Delaware, U.S.A., for the production of the fibre began in December, and production from this plant will probably start in about a year's time.—(*Science*, Vol. 88, No. 2200, pp. 12-14, 1938).

* * *

Boron Treatment of Citrus.

Deficiency of boron has been shown to be the cause of a widespread disease of citrus trees in Southern Rhodesia. The disease, known as 'hard fruit', is associated with spotting of the leaves, thick fruit rind, low juice content, absence of seeds, gumming and discoloration. A. A. Morris (*J. Pom. and Hort. Sci.*, 16, 167; 1938), analysing 21 random leaf samples, has shown that varying boron status is correlated with varying severity of 'hard fruit' incidence. Applications of powdered borax to the soil at rates of 100-500 gm. per tree resulted in rapid increases in the boron content of the leaves, and boron accumulated in the leaves with increasing age. Leaves and fruit from 'hard fruit' trees were found to be low in boron. With the possible exception of nitrogen, it was shown that the intake of the more common nutrient elements by the young citrus fruit does not appear to be influenced by boron treatment. On the other hand, sugars and pectins were lower in boron-deficient fruits than the fruits from trees under relatively low boron treatment. High boron treatment, however, seems to retard rather than assist the translocation of sugars to the fruit. A comparison of treated and control trees shows that severe losses of fruit are occasioned by deficiency of boron, not only during the growing season, but also afterwards in the pack-house. In a particular area, the number of fruits from treated trees was 10,411 whereas the controls yielded only 4,627. The disease, which occurs in areas where the soil is very shallow and subject to marked erosion, is now being controlled on a commercial scale by the application of borax.—(*Nature*, Vol. 142, No. 3597, 1938, pp. 676-677.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Markets have ranged as follows (c.i.f. per cwt.):

	Foreign.		*Preferential*	
	s.	d.	s.	d.
29th December ...	5	6	10	0¾
5th January	6	3¾	10	0¾
12th January	6	3	10	0
19th January	6	3	10	0
26th January	6	3¾	10	0¾
2nd February ...	5	6	10	0
9th February ...	5	6	9	11¼
(10th *February*, 1938) ...	5	2¼	8	10½

The tone of the market has generally been quieter and with no improvement in demand either for raws or refined, prices have moved within a very narrow range. The decision of the Conference of the International Sugar Council, which met on 12th January, to leave the quotas for the current Convention period unchanged has been well received by the market and has dissipated the fears previously entertained that the present favourable balance might be disturbed.

* * *

RUBBER.—Quotations for plantation sheet have ranged as follows:—

	Pence per lb.
28th December	8 3/16
4th January	8 3/16
11th January	8 1/16
18th January	7 15/16
25th January	7 13/16
1st February	7 7/8
8th February	7 11/16
(9th *February*, 1938) ...	6 15/16

In spite of favourable December statistics the market has been rather dull with prices tending slightly downwards. The price decline is mainly attributed to the unfavourable political situation in Europe. Stocks in U.S.A. at the end of December were considerably lower than at the end of November while the figure for consumption, 45,315 tons, is regarded as particularly satisfactory.

* * *

SPICES.—*Pimento* is again firmer with sales made up to 69*s*. c.i.f. for January shipment. Spot London is still unchanged at 8*d*. per lb. *ex* store. Jamaica *Ginger* is easier, prices quoted bring 32*s*. 6*d*. to 35*s*. for mixed to good Bright No. 3 and 37*s*. 6*d*. to 42*s*. 6*d*. for mixed to good Bright No. 2 on the spot in London. The market for *Nutmegs* remains dull and the demand is poorer. Sound unassorted are quoted at 4¾*d*. *ex* store London, with wormy and broken at 2¾*d*. The market for *Mace* is still dull and mixed pale to red descriptions are offered at 1*s*. 6*d*., pale 1*s*. 7*d*., choice pale at 1*s*. 8*d*. and dark broken pickings at 1*d*. to 1*s*.—(*West India Committee Circular*, 12th January, 1939.)

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association.

	American Mid.	*Egyptian Giza 7.*	*F.G.F. Sakel.*
30th December ...	5.25	7.51	7.46
6th January ...	5.30	7.51	7.46
13th January ...	5.19	7.30	7.32
20th January ...	5.18	7.33	7.28
27th January ...	5.17	—	—
3rd February ...	5.13	—	—
10th February ...	5.07	—	—
(11th *February*, 1938)	5.02	7.47	8.27

Although there is little change in market conditions, wider fluctuations have occurred in raw cotton prices which are lower than a month ago. Discussion on the future control of the U.S.A. cotton crop has been centred on the proposal of the Southern Co-operative Associations that the entire loan stock should be eliminated over a period of five years, with a restriction in the area under cultivation to 27 million acres during the period of disposal. In the meantime American cotton continues relatively dear and to an increasing extent spinners are turning to outside growths. A few sales of West Indian Sea Island at between 18½*d*. to 19*d*. have been made.

* * *

COCOA.—During the past month values in consuming centres declined on a comparatively small amount of trading. Offerings from primary markets were less pressing and are likely to continue so, pending improvement in prices, as shippers of both African and Bahia crops are only inclined to sell on a gradual scale upward. Locally the market is exceedingly strong at $7.00 per fanega for Plantation markets due to the small supplies coming to market and Accra is quoted at 21*s*. 9*d*. c.i.f.—(*By Courtesy of the Cocoa Planters' Association of Trinidad, Ltd.*).

* * *

BANANAS.—The price for Jamaicas has fallen to £17 10*s*. delivered London and £17 5*s*. delivered nearest station Provinces. The trade in Brazilians has also been poor, prices dropping to £14 10*s*. delivered London and to £15 delivered Provinces.

* * *

COPRA.—The market is steady. The price of West Indian f.m.s. is quoted at £10 15*s*. for spot and £10 17*s*. 6*d*. for forward.—(*West India Committee Circular*, 12th January, 1939.)

* * *

COFFEE.—Kenyas have met with an improved demand and good prices were realised for the better qualities, bold sizes realising from 73*s*. to 105*s*. per cwt. Tanganyika, cleaned bold size 75*s*., and foreign cleaned A sizes: 58*s*. to 60*s*. per cwt. Santos Superior is slightly easier at 32*s*. and Rio 7 is 23*s*. per cwt.